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Tuan Nguyen

THE YEAR OF THE GRAPHICS CARD

FOR THE LAST FEW YEARS, I've been clamoring for something exciting to happen with PC components. Call me old school, but I'm still hanging on to years gone by, when there were 10 graphics cards companies, 10 soundcard companies, and an intense amount of competition. It felt like we were just boosting clock speeds, and adding non-innovative checklist items to products. I mean, RGB lighting is all the rage recently, but it lacks the *je ne sais quoi.*

But 2016 has been an excellent year for innovation, and the credit goes to VR. When the Rift and Vive looked like they were going to shake things up, I knew we were about to receive a nice shot to the arm in the graphics department. Lo and behold, both AMD and Nvidia are now pushing on that front harder than ever. And thus, we now have on our hands some very bold offerings from both companies, but in very different and complementary directions.

AMD's new Radeon RX 480 breaks the mold in terms of price-performance ratio. Coming in at $200, you're getting excellent 1080p performance, and a very good experience at 1440p. AMD is adamant that its new RX series will help usher in VR at a price point everyone can afford. Although I'm enthusiastic about the company's ambitions, there's still more work to be done on the rest of the system. Getting a headset alone will cost three to four times the cost of an RX 480.

On the high-performance side, Nvidia has gone all out. Its GeForce GTX 1080 and 1070 really shocked the gaming world, and with good reason. Double the performance of two GTX 980 cards, and leapfrogging over a $1,000 Titan X—the old Titan X, anyway—the new GeForces would be happy in any gaming system. But performance isn't the only thing Nvidia has been working on. The new Pascal GPUs also bring along several features that significantly improve performance in VR. And now you also have the company's new GTX 1060, which is pitted directly at AMD's RX 480.

So, is it the right time to upgrade? Actually, right now it's a builder's dream. The new graphics chips from both GPU houses are more affordable than ever. Competition is ripe, and if I were building a new system, I'd probably put my money on a GTX 1080 for a high-end build, and an RX 480 for an entry-level system. All the usual board companies, such as Asus, EVGA, Gigabyte, MSI, Sapphire, XFX, and Zotac, have their own offerings at various prices. When was the last time we had both good pricing and lots of choice?

But, I'm not building a new system. What if you're just upgrading, like me? Well, that would largely depend on what you have now. If you have a GTX 970, 980, or 980 Ti, you're still in pretty good hands. With prices on last-gen cards being axed by the new breeds, it may make sense to go SLI or CrossFire.

In my situation? I'm still rockin' three-way 980 Ti.

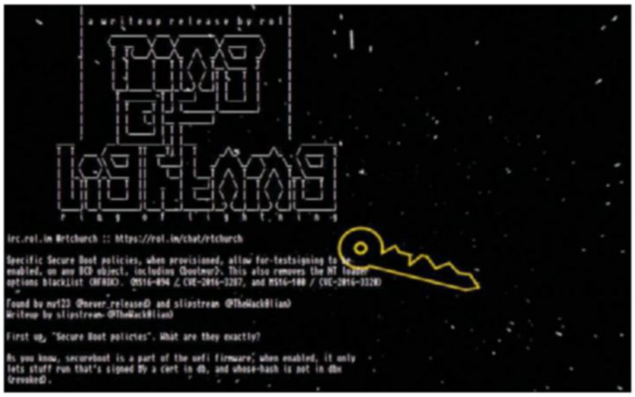
Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Microsoft Loses Its Golden Key

Leak leaves every Secure Boot device vulnerable



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Specific Secure Boot policies, when provisioned, allow for testsigning to be
enabled, on any BCD object, including {bootmgr}. This also removes the NT loader
options blacklist (AFAIK). (MS16-094 / CVE-2016-3287, and MS16-100 / CVE-2016-3320)

Found by my123 (@never_released) and slipstream (@TheWack0lian)
Writeup by slipstream (@TheWack0lian)

First up, "Secure Boot policies". What are they exactly?

As you know, secureboot is a part of the uefi firmware, when enabled, it only
lets stuff run that's signed by a cert in db, and whose hash is not in dbx
(revoked).
```

The *Star Wars*-style blog that reveals how Microsoft left the key to Secure Boot in the retail version of Windows.

TWO "RESEARCHERS" going by the monikers "MY123" and "slipstream" have revealed on their blog a fairly monumental hole in the Windows Secure Boot process—a so-called golden key. This "key" has the potential to be able to unlock every Secure Boot Windows device to allow the installation of other operating systems.

During booting, Windows uses Secure Boot to check that the operating system has a Microsoft certificate and the right policies. The Secure Boot Policy is normally only accessible by Boot Manager. During the development of Windows 10, a new policy was added, to ease testing and debugging, which has its settings merged in, depending on conditions. This policy was shipped with retail Windows versions—accidentally, we assume—sitting dormant in a hidden file. It's knowledge of this new policy that has been leaked.

By editing the new policy, you can bypass certificate checking, effectively unlocking a machine to other OSes and the installation of potentially malicious software deep down in the innards of Windows, where it can live unchallenged. That's the scary part. The fun part is that you can install a new OS on a machine otherwise locked to Windows, such as a Windows Phone, RT tablet, or HoloLens. Windows PCs and servers are generally not locked by Secure Boot.

The bug was reported to Microsoft in March—it even paid a bug bounty. Now the issue is out in the open, and it's all rather embarrassing for Microsoft. The company has millions of systems, and a single key now unlocks them all. It promptly released a security patch, which proved ineffective; another soon followed, and another after that. A clear sign that it is struggling to fix this. Given how close to the boot this vulnerability operates, it's going to be impossible to fix properly—the patches address things after the policy has fired up, so can be bypassed.

It looks as though the problem will never go away. Without physical access to a machine, it's next to impossible to fix the issue, and once something is leaked on to the Internet, it is impossible to get rid of it—just ask Jennifer Lawrence.

Security experts have lined up to berate Microsoft, pointing out that any security system that relies on people, relies on the fallible. The simple existence of any such backdoor key is a huge risk. The pair that have highlighted the flaw had a personal message for the FBI, who recently asked Apple to include backdoors in its systems, after having trouble getting into a suspect's iPhone. The bloggers say that "this is a perfect real-world example about why your idea of backdooring cryptosystems with a 'secure golden key' is very bad!"

Despite generating some alarming headlines—and causing red faces at Redmond—it's not as serious as it might sound. Malicious uses of the so-called golden key are thankfully fairly unlikely, because you need physical access to the machine, administration rights, and to do some low-level tinkering. What it does highlight is the wisdom of building backdoor into any system where security is paramount. Slipstream is right on that count. Meanwhile, if you have a machine locked to Windows that you would like to run something else on, you can. All those Windows phones can be recycled. **–CL**

> “Microsoft has millions of systems, and a single key now unlocks them all.

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Coding war over ads gets even hotter

FACEBOOK STARTED THIS BOUT. The company tried making its web ads indistinguishable from content, to make Adblock's job more difficult. In exchange, users got the option to use Ad Preferences to block ads from specified businesses. The company claimed that people blocked ads because they are disruptive and slow, not because they don't want to see them. Part of its mission is to "create connections between people and businesses."

The move didn't go down well, and a new filter for Adblock Plus appeared within a day or two, which circumnavigated the Facebook trickery. Adblock once again removed the ads from Facebook's sidebar and news feed. It was not a perfect solution, and Facebook warned that it may also remove posts from friends and pages. Facebook went to work to block the block on the block. A back and forth fight soon developed, each side trying to circumnavigate the other.

To comply with FTC rules, ads have to be identifiable, and that means Adblock always has something to work with—it's just a matter of finding out how Facebook identifies them. Currently, both sides are busy coding to defeat the other, with the "winner" changing every few days.

Adblock is used by over 200 million people worldwide, and is a major annoyance for commercial operations because it directly affects the bottom line. As Adblock's Ben Williams put it, "This sort of back-and-forth battle between the open-source ad-blocking community and circumventers has been going on since ad-blocking was invented."

It's a classic contest, between libertarians and commerce. On one side, we have the freedom from ads, from being tracked, slowed down, and annoyed. On the other, we have companies being stopped from receiving fair compensation for services, being effectively held to ransom by a third party. Neither side looks likely to relent, or ultimately to win, either. **–CL**

KABY LAKE AND ZEN WITH BUILDERS

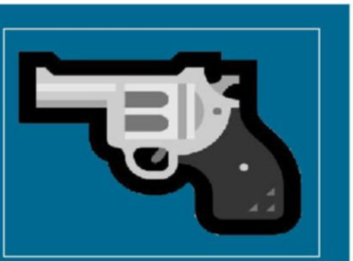
SEVENTH GENERATION IS HERE

PROCESSORS BASED ON INTEL'S KABY LAKE ARCHITECTURE have begun to ship to PC builders, so we will see the first systems using this 14nm seventh-gen core later this year. It's a development of the Skylake design, and will come in the usual i3, i5, and i7 flavors, with up to four cores. Only Windows 10 is supported. Meanwhile, AMD's Zen architecture will also put in an appearance later in the year, although consumer desktop systems won't be available until next year. It's also a 14nm process, and a completely fresh design. It'll power a range of high-end processors code-named Summit Ridge, with up to eight cores.

Kaby Lake and Zen architectures will be used as the basis of a wide range of chips under various names, from servers and high-end desktops through to mobiles. Both will hit the market in real numbers at about the same time, so expect an old-fashioned AMD versus Intel head-to-head. Excellent. **–CL**

EMOJI SHOOT-OUT

Is it a toy or a gun?



THE PISTOL EMOJI is a contentious one—the New Yorkers Against Gun Violence organization ran a Disarm the iPhone campaign against it. Apple has responded by changing it to a more friendly squirt gun in iOS 10 beta, along with 100 other new emojis aimed mostly at gender equality and diversity.

Microsoft had used a toy ray gun image previously, but with the release of Windows 10 Anniversary Update, this was replaced by a realistic-looking pistol. The pair are moving in exact opposite directions. Cross-platform confusion looks likely as previously innocent iPhone messages can look much more menacing on your Windows system.

The Apple change has drawn much criticism and is only a beta, so perhaps the pair can get in step, and decide whether or not to make it look realistic. The other firearm emoji, the rifle, was dropped with Unicode 9.0 earlier this year. Of course, we still have knives, swords, poison, and bomb emojis to play with. **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

WORLD'S BIGGEST SSD DRIVE
Seagate has built a monstrous 60TB SSD drive, four times bigger than the previous record holder, from Samsung. A commercial version is due next year.

ATOMIC-SCALE HDD
Researchers have found a way to write data with single chlorine atoms on copper, increasing data density by 500 times. But it does require -321 C.

STREAMING PLAYSTATION
You'll soon be able to play PlayStation 3 games on PC via PlayStation Now, although Europeans will get first go.

TRAGEDIES

HACK CAN OPEN VWs
A security company has revealed a hack that can open 100 million VW cars using $30-worth of hardware to intercept the key fob signal.

CHROME TO LOSE FLASH
Chrome is to drop all Flash support by the end of the year. Ten sites will be spared—all others will have to have it manually activated.

SNAPCHAT RACISM (AGAIN)
Snapchat has dropped a new face filter. Dubbed "yellowface," it was seen to caricature East Asians.

Jarred Walton

TECH TALK

Is Microsoft's Dominance Set to End Soon?

WINDOWS HAS BEEN the leading OS for so long that many people have never used anything else. My first computing device was a Magnavox Odyssey II, before moving to the Commodore 64. I switched to DOS PCs in the late ’80s, with hard drives that left floppies sucking dust, and never looked back.

The rise of mobile devices poses the greatest threat Windows has ever faced.

Windows became the friendlier face of Microsoft, and while it hasn’t been the only choice—various flavors of Unix/Linux and Apple’s MacOS and OS X have always been around—outside of servers and workstations, most PCs in the workforce have been running Windows or DOS for over 30 years.

That dominance is eroding, and it’s not a competing desktop or laptop OS that’s closing in on Windows—it’s the rising tide of Android and iOS. When Apple created the first touchscreen smartphone in 2007, it clearly had the potential to change the way we looked at technology, but it was still very slow and had some obvious flaws. Google released Android about a year later, and again it showed promise, but had clear limitations. Nine years of innovation for both platforms have created the biggest threat Microsoft has ever faced—and, by all metrics, Microsoft is losing this battle.

Data from Netmarketshare over the past five years shows that Microsoft Windows has dropped from 88 percent to just 63 percent of total Internet traffic. Currently, mobile OSes represent nearly 30 percent of all web traffic, and mobile Windows hasn’t managed to gain any traction—Android and iOS combined snag 94 percent of the mobile OS market, with Android controlling the lion’s share at 66 percent. Even accounting for margin of error in the data collection methods, the numbers represent a sea change whose impact is only beginning to be felt.

> “Nine years of innovation have created the biggest threat Microsoft has ever faced

A big reason for the shift is the convenience of mobile devices, and while software is important, the hardware story is equally if not more meaningful. As hardware enthusiasts, we’ve seen massive leaps in performance over the past few decades. But for average Joe users, hardware requirements have been sitting on a plateau for several years. I still have an i7-920 in use and running Windows 10 just fine, thank-you-very-much. That’s an eight-year-old part, helped by a GPU and SSD upgrade, but back in the ’90s, I wouldn’t have been caught dead with such an old “clunker”!

Desktop and laptop CPUs have seen moderate 5–10 percent improvements per year over the past decade, and mobile processors have dramatically narrowed the gap. For example, Apple’s A9 SoC found in the iPhone 6S/SE line is around 70 percent faster than the previous A8 chip, and the A8 is about 50 times faster than the original iPhone’s S5L8900. Small wonder, then, that many find current smartphones are quickly approaching the “fast enough” era, with Apple’s A9X not far behind Core M Skylake parts.

At the current rate, sometime in the next four years, mobile OS use will likely pass Windows. It’s a brave new world in our always-on, always-connected digital lifestyle, and Microsoft isn’t in the driver’s seat anymore. The good news is there will always be a place for high-performance systems, because a handheld device will never beat a system consuming 100 times as much power—something has to sit in the background running all of the infrastructure, after all. But I suspect, in another 20 years, people will look at desktops and even laptops the same way we look at the refrigerator-sized mainframes of the ’70s: relics of a bygone era.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

ENERMAX

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2016 Innovation

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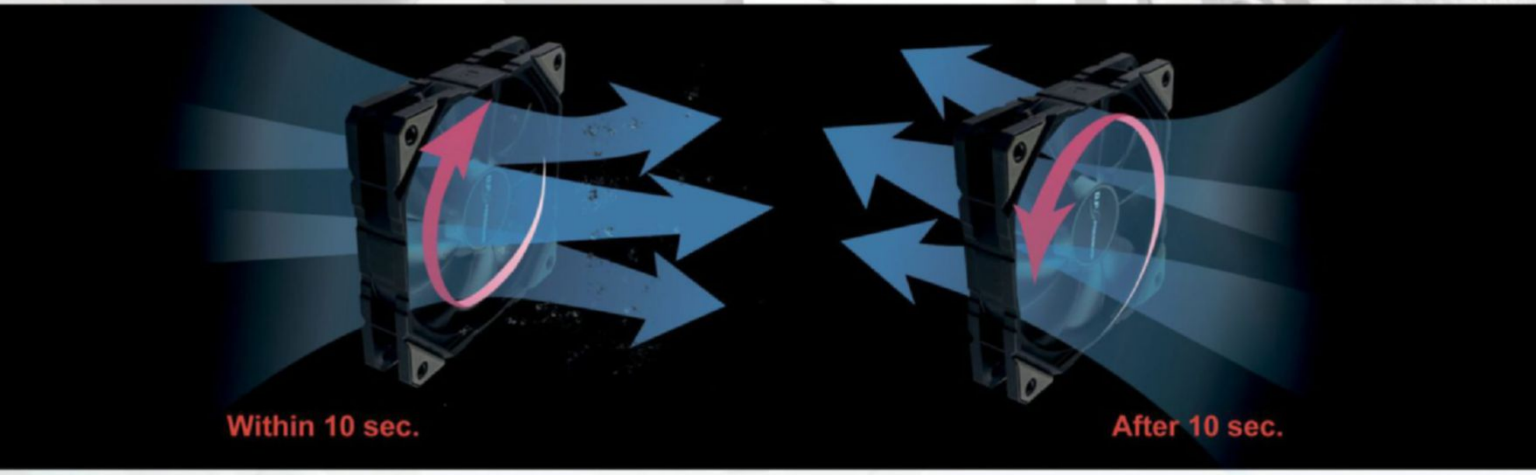

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Platimax D.F.

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Twister Bearing Fan

OSTROG ADV

MaxBrite™ technlogy brings
the world first case with
LED lighting in the front
and top panel!

Alex Campbell

OPEN SOURCE

The Double-Pointed Nature of Forks

IT STARTED OUT INNOCENTLY ENOUGH. There I was, setting up my VPS with Docker, getting my blog and other services running. Eventually, it came time for me to install OwnCloud (an open-source cloud project that offers a replacement for things like Dropbox and Google Drive), so I headed over to Docker Hub to look for the right container to pull.

I looked at the most popular container that wasn't the official one provided by OwnCloud. With over 100,000 pulls, the l3iggs/owncloud container seemed to be the way to go. But there was one major hiccup: A June 4 update mentioned that some OwnCloud developers had left to start their own company—Nextcloud—to work on a fork of OwnCloud.

For those new to open source, a fork is a big deal. It's common for developers to pull code from a project and work on a specific feature of bugfix in their own branch of the project. That code is usually merged back into the main branch, which is the code in the end product that users typically run. A fork, on the other hand, is like a branch, except that it abandons the main project entirely, and uses the branched code as a base for the new project. The fork's code is maintained separately from the project it is forked from, and usually has different leadership and mission objectives. Project forks can eventually totally revamp the code base, if needed.

If you've been using free and open-source software for a while, there have been a few famous forks to note. LibreOffice and MariaDB forked from OpenOffice and MySQL respectively, after Oracle acquired those two. More recently, the Chromium team started Blink, a fork of the WebKit rendering engine (that powers Chrome and Safari). Plex is a proprietary fork of the popular HTPC software XBMC (now known as Kodi). Even the popular WordPress is a fork from b2/CafeLog.

Forks can be disruptive, but they're common in the open-source world.

> Forking can create strife, as developers are forced to choose sides by deciding which project they will contribute code to

Forking a project can create a lot of strife, as developers are often forced to choose sides by deciding which project they will contribute code to. This is the case with the OwnCloud fork, which saw one of OwnCloud's co-founders split off to form Nextcloud, bringing a large number of developers with him.

Users are faced with problems whenever there is a fork, too. Users of the old software have to choose whether to continue with the current product, or switch to the new one. Compatibility becomes an issue over time, so this choice can become time-sensitive, as the fork and original projects release new versions. New users or users looking to install software on clean systems are faced with a similar problem. When presented with two similar packages, they have to make a choice about which project will be better maintained in the future. While this can be predicted by looking at the number of contributors, pulls, and commits for a project on GitHub, few users look at those numbers when wanting to type a simple apt-get install. Also, forked projects often have to play catch-up to provide mobile apps, official binary packages, and official Docker containers.

So, is it better to go with a fork? Maybe. Major forked projects that I've listed, such as WordPress, LibreOffice, and MariaDB, are better maintained than the projects they originated from. But forking is never a smooth path, and the fork may experience bumps in the road as it tries to find its footing. For projects like Nextcloud, that you'll be entrusting your data to, it's a good idea to keep backups of your data, just in case something breaks.

As for my VPS, I'll install Nextcloud (via the greyltc/nextcloud Docker container), fingers crossed.

Alex Campbell is a Linux geek who enjoys learning about computer security.

CREATIVE COMMONS PHOTO: DAVID JOHNS

TALKING

BY **ZAK STOREY**

AMD Dives into Polaris for us

Maximum PC grills AMD's Jason Megit on exactly what makes Polaris tick.

This year has seen some of the craziest advancements in graphics performance since both manufacturers jumped down from 40nm to 28nm. We sat down with Jason Megit, AMD's Technical Marketing Manager, to get some insight into why Polaris and its new 14nm architecture is such a revolutionary step for the company.

Jason Megit certainly knows his stuff when it comes to AMD GPUs.

Maximum PC: Can you tell us a little bit about Polaris' design process? Where do you start? How does an architecture develop over time?

Jason Megit: The design process for Polaris began over three years ago, at which point we spent a great deal of time looking at our current product specifications and trying to project forward into the future and understand the types of use-cases and resulting performance requirements that would be asked of our product in two years time. Our architects and engineers then needed to make sense of how technologies such as manufacturing processes, memory availability, and new input/output standards were going to affect our ability to deliver on certain design characteristics or requirements.

In Polaris' case, the writing was on the wall for our architects three years ago: 1080p was rapidly becoming the minimum standard gaming resolution for the PC platform. One key technology that we also saw on the horizon was VR. Designing for VR involved choices such as: which display outputs do we need to support? At what bandwidth? How can we reduce latency? What frame rate should we aim for and in what types of workloads? This is where we buckled down and drove towards an understanding of the level of performance we needed to aim for. We hit the mark with Polaris, with the Radeon RX 480 becoming the industry's first sub-$200 premium VR-capable GPU.

MPC: What do you believe is the most innovative feature introduced with Polaris 10 and 11?

JM: Polaris includes a couple of new features to ensure higher quality game streams or captures: First, Polaris adds video encode acceleration support for HEVC, supporting up to 1080p @ 240Hz, 1440p @ 120Hz, or 4K @ 60Hz. Polaris is equipped with the encoding horsepower to capture or stream a high-quality and beyond HD game stream.

To complement this world-class video encoding feature set, Polaris further improves game stream quality through the use of two-pass encoding. Two-pass encoding in Polaris allows for real-time picture-level analysis of the game content you are streaming/capturing resulting in richer quality video captures of your gaming experience. If you've ever experienced a game stream going blocky during quick scene transitions, or complex objects like bushes in the distance looking blurry, 2-pass encoding can solve some of the encoding issues that cause these problems.

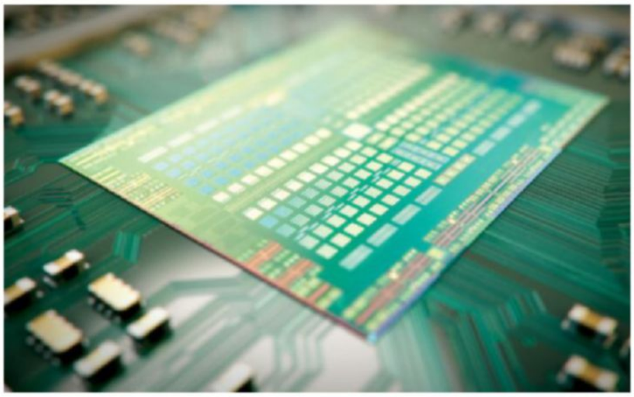
MPC: We've been hearing a lot about Asynchronous Compute with QRQ; could you go into detail about how it operates?

JM: AMD's Graphics Core Next (GCN) architecture can actually handle the balancing of processing within the graphics and compute command queues in three different manners: concurrent compute and graphics execution, compute preemption of graphics, and priority compute (or QRQ). In contrast, the competition only provides developers with one option (compute preemption). This level of choice for asynchronous compute techniques offered to developers by AMD's GCN Architecture is exactly why applications like the DirectX 12–equipped *Ashes of the Singularity* gain so much performance on AMD hardware when comparing to DirectX 11.

Quick Response Queue (QRQ) is the third method that AMD's GCN exposes to developers for handling the parallel processing of compute and graphics command queues. QRQ allows for developers to give preferential treatment to certain commands in the queue, ensuring they are executed in a timely fashion. A great example of the type of workload that benefits greatly from QRQ is TrueAudio Next. Latency is incredibly important to audio workloads and QRQ gives developers the option to enforce a guaranteed latency on audio workloads that are being executed on the GPU.

MPC: Can you explain to us how TrueAudio Next works, and how important it is for Virtual Reality?

JM: With the widespread introduction of VR HMDs this year, we are truly looking at an exciting time for audio in real-time immersive content. One of the key reasons why VR is so interesting is because it allows for us to reach new levels of immersion that were impossible with a simple 2D screen on a desktop. That being said, when you increase immersion through new interaction techniques (head tracking) and display techniques (lens, stereo3D, and HMDs) – other areas of sensory input become that much more important.



The epic gloriousness under the hood of Polaris 10.

With AMD TrueAudio Next, we are addressing the need for more immersive audio to complement VR experiences. TrueAudio Next makes use of a feature unique to AMD's GCN architecture—CU Reservation. This feature allows for a certain number of CU's (Compute Units) within your GPU to be reserved for the purposes of dealing with a real-time audio queue of commands.

CU Reservation is needed for TrueAudio Next due to the importance of real-time processing for audio. A certain priority needs to be given to the audio queue to ensure that all processing is taken care of in a timely fashion—if you miss a deadline with audio, it makes itself known to your ears through some nasty, glitch-ridden sound. With this approach to isolating audio workloads from graphics workloads, TrueAudio Next can provide a glitch-free convolution filter with latency as low as 1.33ms (or 64 samples @ 48kHz).

MPC: You're using delta color compression to help reduce overall memory bandwidth through the 256-bit memory bus—how does that impact overall performance?

JM: If you consider a typical game world, you may have a lot of green-colored objects at certain portion of each frame (i.e. grass and vegetation), a lot of blues at another portion of the frame (the sky or water), and potentially a lot of blacks or greys in other areas (your character, a car's dashboard in a racing game, or a weapon your character is wielding). Without DCC, the GPU would have to store the full color information for each pixel in the frame. With DCC, Polaris products are able to take advantage of the fact that colors are more likely to be similar or only gradually change in similar areas of a frame.

So, in AMD's 4th generation of the GCN architecture, we are able to look at a single frame as a section of separate smaller blocks. The GPU hardware and driver then work together to make intelligent decisions on each of these blocks to assign one color, with all other pixels in that block being defined as the delta from that block's assigned color. A delta is much easier to store (and therefore move around) due to its reduced size in comparison to storing the full color information. This compression technique is utilizing deltas and not actually changing the source coloring. It is therefore lossless and essentially means that we can move up to 35%* more data across the memory bus.

MPC: Arguably this year has seen some of the biggest advancements in performance-per-watt since 2010. Where do you see graphics processors heading in the next five years?

JM: I certainly agree with that qualifier. This year has indeed been exciting for those that consider performance-per-watt a key variable in their GPU purchasing decisions. Not only are we able to offer Polaris products at amazing price points, but we are also able to enable new form factors and designs based on reduced thermal requirements.

A major contributor to performance-per-watt metrics with graphics card is the manufacturing process used to create the chip at its heart. Previously, we made a shift from 40nm to 28nm (early 2012) which resulted in impressive gains on the performance-per-watt front. With the RX 480, RX 470 and RX 460, we have shifted from a 28nm process to 14nm FinFET process.

The 14nm FinFET process offers a significant step forward in reducing operating voltages and leakages in comparison to the 28nm process that came before it. The 14nm FinFET process utilizes 3D transistors

ZEN
AMD
AMD
AMD
AMD

Zen looks to complement AMD's recent success with Polaris.

to both increase performance whilst reducing the total power required per transistor. The end result is that AMD's architects were able to pack more transistors into a tight space all while requiring less power per transistor.

MPC: With Intel struggling to maintain its Tick-Tock manufacturing process, how difficult is it going to be to transcend below 14nm from a GPU point of view?

JM: It's no secret to those with knowledge about the key metrics in performance and efficiency tied to GPUs that the specific manufacturing process being used is typically the primary influencer in pushing these metrics forward. That being said, major manufacturing changes are not dictated by AMD; we just shifted to the 14nm process for Polaris and previously spent roughly 4 years at 28nm.

I personally can't wait to see sub-14nm chips and whatever comes after that. But in the meantime, we must think of the ways that we can get the most out of current manufacturing technologies. There are plenty of opportunities in terms of design optimization in hardware and software to ensure this can happen going forward. Our technologies will not stop moving forward, especially given the increased demands that 4K and VR will place on our products over the next couple of years.

From a GPU-specific point of view I am very excited about the massive opportunities for optimization on the software side with our current 14nm products. Technologies such as AMD LiquidVR, DirectX 12, and Vulkan give developers improved access and control over GPUs are making a huge difference already and there is still more to come in the immediate future.

MPC: We've seen a big push lately towards HDR color. How important do you see that being in the graphical evolution?

JM: Constantly driving the industry towards new display technologies and visualization techniques is absolutely paramount to AMD's Radeon Technology Group's overall graphics strategy. As a leader in providing the world with graphics hardware, it is in no small part AMD's responsibility to ensure that new technologies like HDR are well-supported. Without the underlying hardware/software to support new technologies, there will be minimal incentive for display vendors to push these new technologies into their latest hardware.

If you look at the previous decade in terms of display technology, a tremendous amount of focus has been on the increasing overall resolutions and refresh rates. Luminance, in my opinion, has not been given its fair share of the excitement. After seeing a few HDR displays in action last May during Polaris Tech Day in Macau, I truly believe that this is about to change.

Our eyes are able to detect objects based on the photons of light bouncing off of them and hitting our retinas. We are able to differentiate between different objects in ratios, this is often referred to as a contrast ratio in the world of display technologies. Right now, most typical displays are capable of displaying 667:1 contrast ratio, however HDR displays will be capable of increasing this ratio from 20,000:1 and up to 20,000,000:1.

MPC: FreeSync seems to be improving quite rapidly, especially with the launch of DisplayPort 1.3 and 1.4. What improvements are being made to avoid ghosting, and other color anomalies?

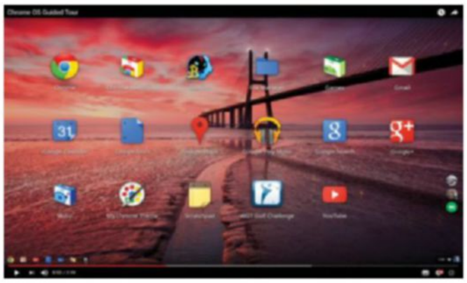
JM: I personally believe that AMD has been at the forefront of display technologies for years, especially considering our history with AMD Eyefinity technology and DisplayPort. Recently, we have made great improvements to the FreeSync ecosystem by enabling an industry-first option for variable refresh rates being driven over an HDMI-linked display. We have accomplished this by implementing vendor-specific extensions to the HDMI standard to add new features. This support will be rolled out across many different HDMI display models, which can be viewed at our FreeSync product page (http://amd.com/freesync/). Further, FreeSync now supports Low Framerate Compensation (LFC) to enable smoother gameplay when your games frame rates fall below the minimum refresh rates supported by your FreeSync display. This is supported through an adaptive set of software that gracefully handles sudden drops in frame rates and is automatically enabled on all AMD FreeSync-ready monitors.

In terms of ghosting and other color anomalies, these were typically handled by the scaler vendor specific to your FreeSync-ready panel. Our FreeSync partners have been quick to update their scaler firmware to address this, some have even gone above and beyond and offered further tunings or optimizations. We believe that the panel vendors should be given the control and capabilities necessary to tune their scalers and panels for the best possible performance. This is in my opinion the beauty of an ever-evolving and open ecosystem such as FreeSync: there are constant improvements and creative new features being introduced that serve to only improve our experience and enjoyment of our display investments.

** Based on AMD internal memory bandwidth test as of 6/14/2016. Radeon R9 290X: 263GB/s peak memory bandwidth. Radeon R9 Fury: 333 peak GB/s without DCC vs. 387 peak GB/s with DCC. Radeon RX 480: 186 peak GB/s without DCC vs. 251 peak GB/s with DCC. System configuration: Core i7-6700K, 16GB DDR4-2666, Windows 10 x64, Radeon Software 16.5.2.*

THE LIST

THE BEST OPERATING SYSTEMS YOU CAN INSTALL TODAY



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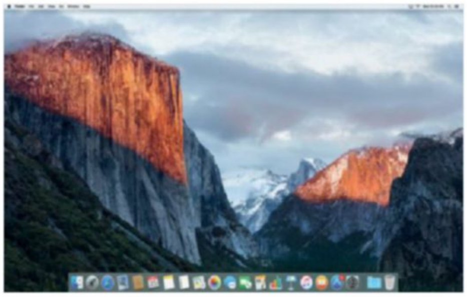
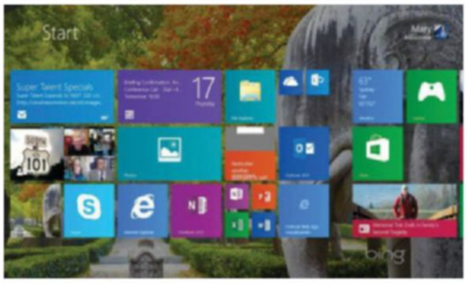
CHROMIUM OS Give that old laptop a new lease on life with this stripped-down, open-source, speedy OS.



7

MAC OS X Our illustrious editor-in-chief swears by his Hackintosh, whereas most of us just swear at it.



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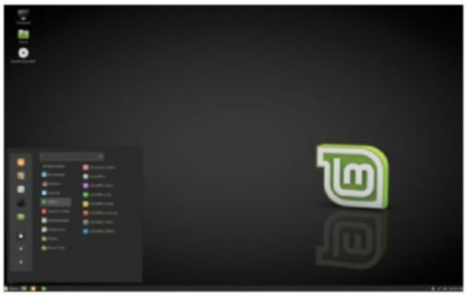
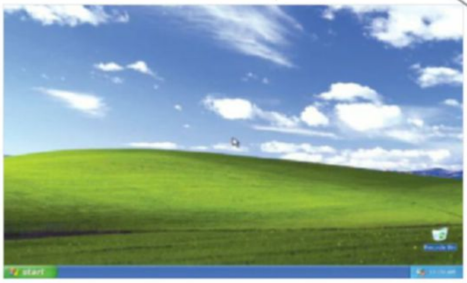
WINDOWS 8.1 Windows 8 had a faltering launch, but that big patch sorted out most of its problems.



5

LINUX MINT 18 It may live in Ubuntu's shadow, but Mint is easy to use, looks good, and is secure.



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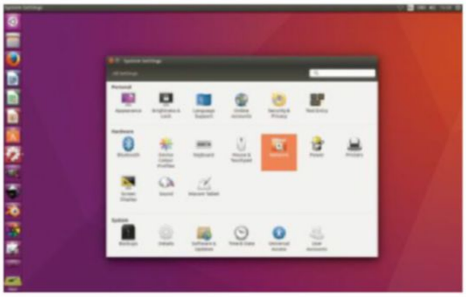
WINDOWS XP It's old and lacks support, but we'll always have a soft spot for this excellent OS.



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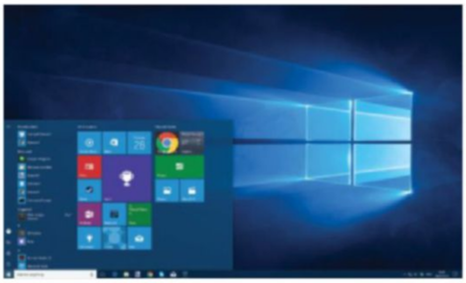
UBUNTU 16.04 LTS Canonical's latest closes in on Windows, at least from an OS perspective.



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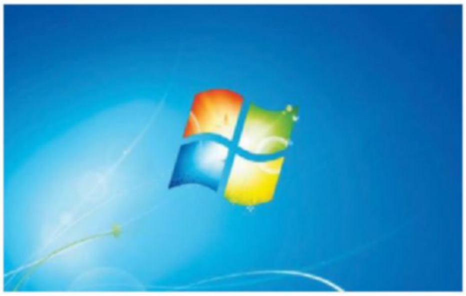
WINDOWS 10 The anniversary patch improves matters, but until DX12 takes off, it's kept off the top spot.



1

WINDOWS 7 Microsoft's best OS? We think so. It'll bow to Win 10 ultimately, but it still has the edge now.

DOCTOR

THIS MONTH THE DOCTOR TACKLES…

> Postponed Polaris
> Choosing a GPU
> Antivirus Solutions

MSI's GeForce GTX 1070 Sea Hawk uses closed-loop liquid cooling, saving you the hassle of building your own water-cooled setup.

Waiting for Polaris

Dear Doctor, after reading *Maximum PC's* May 2016 review of Skylake-compatible motherboards, I decided to build a gaming machine in a Mini-ITX form factor. The plan was to purchase Asus's Z170I Pro Gaming, which you reviewed. But, after looking at all of that company's products, I went with the Maximus VIII Impact instead.

At this point, I have all of the parts to go with it, except for a graphics card. My son recommended that I wait for AMD's Radeon RX 480 8GB, so I put off finishing the machine for now. Unfortunately, they're all sold out! Now I need your advice: Should I keep waiting until availability improves, or go with another card?

The games I am playing include *Civilization V* and *Beyond Earth*, *Elder Scrolls Online*, *Fallout 4*, *Kerbal Space Program*, and *War of Warships*. For now, I'm pleasantly surprised at how well Intel's HD Graphics 530 work; only *Fallout 4* is unplayable.

I want this system to be fast enough that it handles new games for the next two to three years. Also, the Maximus motherboard comes with a U.2 connector instead of M.2, and I haven't found many corresponding SSDs. Any advice you can provide on U.2 would be welcome (including whether it's worth the cost).

My old system included a Core i7-4820K on an Asus X79-Deluxe motherboard, 16GB of memory, an MSI Radeon R9 270, a 480GB Crucial M500 SSD, and some Western Digital hard drives for user storage. The new one sports a Core i7-6700, 16GB of G.Skill DDR4-3200, a 1TB SanDisk X400 SSD, and a Cooler Master G750M, all in a Corsair Obsidian 250D case. I carried over an HP w2207h monitor, too. **–Thomas Eddy**

THE DOCTOR RESPONDS: Your old machine and new one feature very fast processors, lots of RAM, and quick storage. A beefy GPU would normally be the ticket for well-rounded performance. But you're using a monitor with a native resolution of 1680x1050. No wonder Intel's HD Graphics 530 seems fast enough in most games.

Consider a 24- or 27-inch display with a native resolution of 1920x1080, at least. You'll get more desktop space and sharper-looking visuals. At that point, it makes sense to snag a Radeon RX 480—they should be more readily available by the time you read this.

As far as storage is concerned, Intel's 750-series SSDs include U.2 cables for PCI Express-based transfers. They're expensive, but you have to love the thought of sequential read speeds in excess of 2 GB/s!

Picking the Right GPU

Hi Doc, I am hoping you can provide some help on an upcoming decision. Currently, I own an older PC with a Core 2 Extreme QX9650, overclocked to 3.8GHz, on an Asus Maximus Formula SE motherboard. I'm also using 4GB of DDR2-6400, and an XFX Radeon HD 6770 graphics card. Surprisingly, it all behaves well enough under Windows 10.

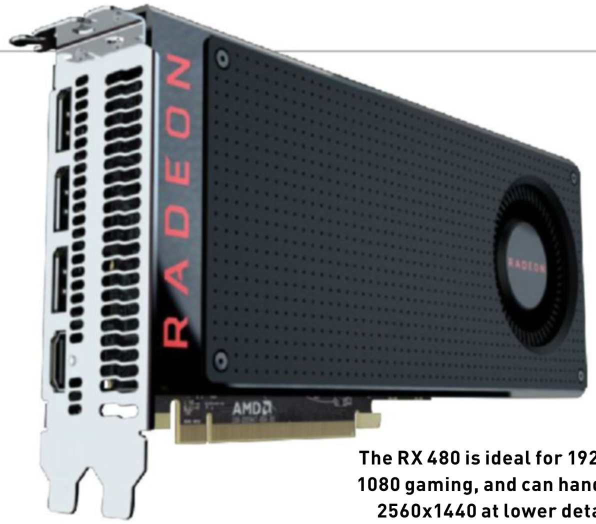
However, I'm gearing up to build a new machine with a Core i7-6700K on an Asus Maximus VIII Formula or Maximus VIII Extreme. Is there a GPU from AMD that I can use to upgrade my current PC, and then swap over when I finish building its replacement? Is going that route even worthwhile, or should I just wait and get the best GPU I can afford for the new machine? I'd like to water-cool the new card, and my budget is in the $400 to $600 range. Any insight you can give would be great.

–Anthony Sambuco

THE DOCTOR RESPONDS: There are only a couple of cards that fall within your budget—the Radeon R9 Fury and Fury X—and the Doc would not recommend either of them. Both are simply too expensive compared to Nvidia's GeForce GTX 1070, which is faster than AMD's flagship, and priced more aggressively.

MSI sells two versions of the 1070 you might like. One

↘ submit your questions to: doctor@maximumpc.com (the Sea Hawk X) includes closed-loop liquid cooling, incorporating its own block, pump, tubing, radiator, and fan, saving you the hassle of piecing together parts. The other (the Sea Hawk EK X) comes with a water block built on to the PCB, which you'd tie into your own cooling loop.



The RX 480 is ideal for 1920x 1080 gaming, and can handle 2560x1440 at lower detail.

Staying Safe

Hi Doctor, I have a silly question. I just picked up an inexpensive Windows 10-based tablet that I'm using for work (it runs all of my automotive diagnostic software), and I need a lightweight antivirus app for it. At home, I use Kaspersky, but that's just too bloated, and I'm not going to use it on this tablet. After all, it only has a quad-core Atom inside, with 2GB of RAM. I'm not necessarily looking for free software; I have no problem paying for a capable antivirus solution. **–Paul Kadron**

THE DOCTOR RESPONDS: Bitdefender gets a lot of praise, and not only for its business solutions. The company's Internet Security and Antivirus Plus products are also well regarded. But it's difficult to say in absolute terms how either suite (or any competing utility) will affect the performance of an Atom-powered tablet.

Truth be told, the Doc lets Defender run in the background of his Windows-based devices, even though most folks rip on Microsoft's free software. An ounce of prevention is worth a pound of cure, and if you're careful with the links you click, the attachments you open, and the sites you visit, the reasons to run performance-robbing security suites start melting away—even more so if you're using the tablet for a specific purpose like automotive diagnostics. Not convinced? Bitdefender will sell you its least-expensive solution for right around $35.

Decisions, Decisions

Dear Doctor, I have two similar computers that I built back in 2011 and 2012. Their current specs are listed below. I am contemplating putting new CPUs, motherboards, and memory in each, and I'm not sure which ones to pick. Right now, the options are Intel's Core i7-6700K, 5820K, and 6800K. Or, should I bite the bullet and go with a 5930K/6850K? Is the extra performance worth a higher price tag? There's a $200 to $300 difference in there, so I don't want to waste money. For what it's worth, I'll be buying a GeForce GTX 1070 or 1080 down the road. I do a lot of gaming now, and while I'm not running at 4K or anything, I do use 1920x1080 monitors. In the end, I'm hoping for a PC I can enjoy four or five years from now.

The first PC has a Core i7-2600K, a 240GB Mushkin SSD, a Gigabyte GeForce GTX 970 4GB G1 OC, Asus's P8Z77-V Z77-based motherboard, 32GB of G.Skill Sniper DDR3-1600 RAM, a PC Power and Cooling 750W power supply, and Corsair's H100i GTX closed-loop cooler.

The second is based on an Asus P8Z77-V LE motherboard, with a Core i7-3770K processor and 32GB of G.Skill DDR3-1600 installed. Like the first system, this one has a 240GB Mushkin SSD, Gigabyte GeForce GTX 970 4GB, and Corsair H100i GTX cooler. **–Robert Klaas**

THE DOCTOR RESPONDS: Just to be clear, Robert, Intel's Core i7-6700K is based on the Skylake architecture, and drops into an LGA 1151 interface. Core i7-5820K and 5930K are Haswell-E-based and utilize LGA 2011-v3. Core i7-6800K and 6850K are Broadwell-E CPUs; they work with LGA 2011-v3 as well (though you'll typically need a firmware update for older X99 motherboards).

If you're a gamer first and foremost, save some cash on those workstation-class processors and snag a Core i7-6700K, obviously replacing the 2600K before the 3770K. Most games don't know what to do with more than four cores, and Intel's Skylake design is the highest-performing per clock cycle available. Further, the money you save on a 6700K can go into a faster graphics card. The GeForce GTX 1080's advantage over the 1070 is far greater than any influence a CPU might have.

Then again, at 1920x1080, Nvidia's GP104 GPU is overkill. The Doctor definitely prescribes a monitor upgrade, too.

Aging Gracefully

Hello Doc. I just read the September edition, and noticed that, in his letter to you, Michel Cauvin suggested he might be the oldest reader of *Maximum PC*. Being 78 myself, I thought it might be interesting to see how many World War II-vintage readers there are from that era or earlier. I started an electronics hobby around age 10, and have kept it going ever since then. So far, I've only built one computer (an Altair 8800 kit), but I am about to put together a PC.

There is one question I have for you: How does one size a power supply properly? Adding up the maximum loads of every attached component is easy enough, but my motherboard manual (for Gigabyte's Z170X-Gaming GT) is of no help when I try to factor it in to my calculation. I suspect that an allowance for future expansion, plus a safety factor of at least 30 percent, would work, right? Any direction you could provide would be great. **–John Fertig**

THE DOCTOR RESPONDS: Emails like yours are some of the Doc's favorite, John. Thank you for showing us that passion is lifelong, even though technology moves at a breakneck pace.

There are a number of factors to consider as you size a power supply. One is the maximum draw of each component behind the PSU. As you no doubt already know, host processors and graphics cards are the most conspicuous consumers; it's relatively easy to find detailed power specs on those parts. System memory, fans, and storage are more minor variables, but also worth adding up. And you're right—motherboard manufacturers don't typically provide power information. Depending on the subsystems you're using, that ceiling can rise and fall. Ultimately, though, 40 or 50W as an upper bound should be safe for a high-end PC.

Remember that you aren't sizing your PSU just so you know it has enough capacity when your components are working their hardest. You're also looking to optimize efficiency (thereby minimizing waste heat) under load and at idle. A quick look at the 80 PLUS organization's certifications illustrates that a PSU operating at 50 percent of its rated load is typically more efficient than one at 100 percent or 20 percent.

So, for example, if your PC's parts need 500W, and you have a 1kW 80 PLUS Gold PSU able to achieve 90 percent efficiency at 50 percent load, you're pulling 555W from the wall. If you have a 750W 80 PLUS-rated PSU certified for 80 percent efficiency, the same parts draw 625W. Strike the right balance, and you'll save on electricity without overspending on too big a PSU.

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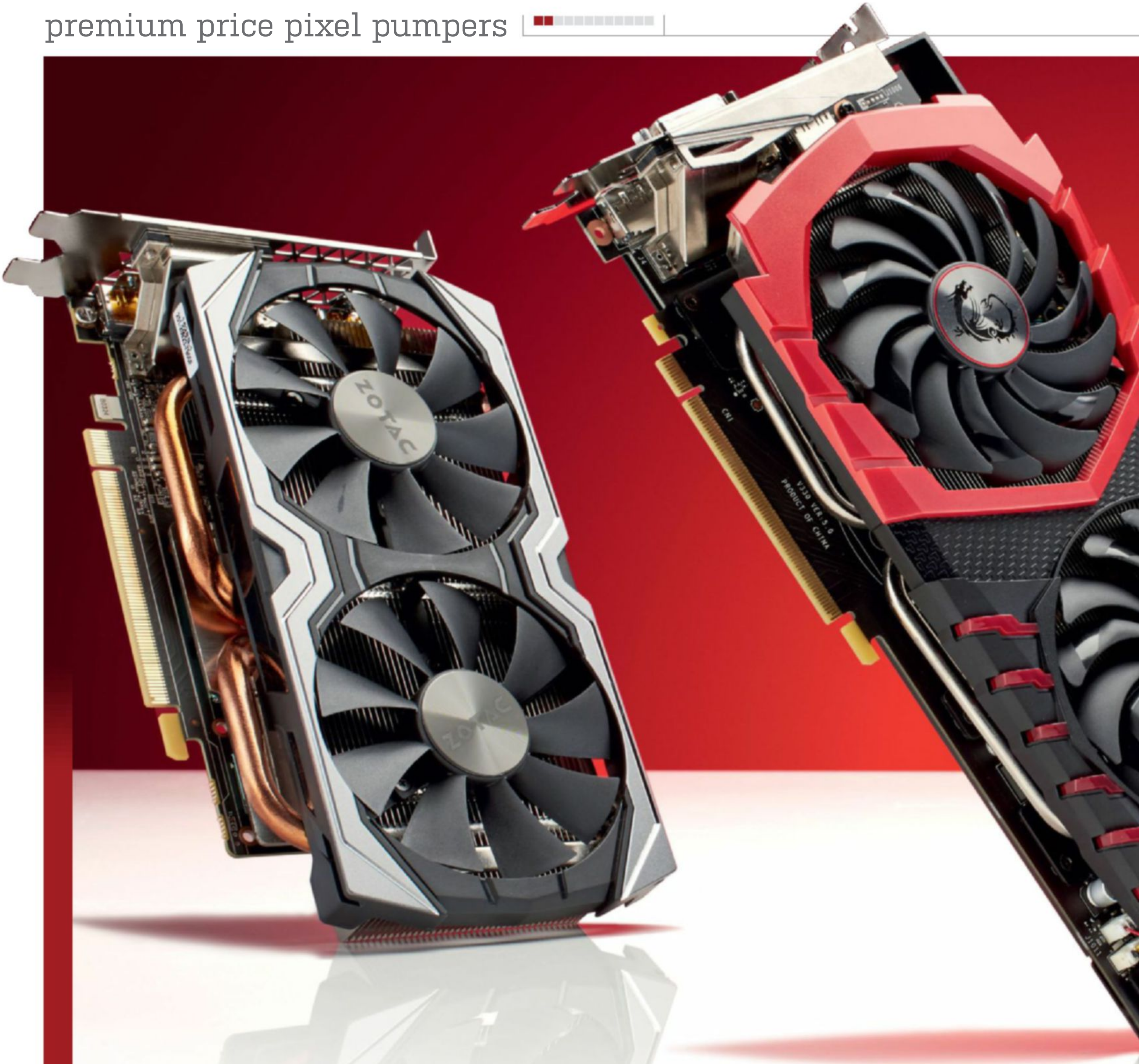
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PREMIUM PRICE PIXEL PUMPERS

AMD and Nvidia are at it again, but this time they're aiming at opposite ends of the market! *By Jeremy Laird & Zak Storey*

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JUST WHEN WE THOUGHT MOORE'S LAW was history, that gaming graphics was grinding to a halt, it's happened. Finally, belatedly, both AMD and Nvidia are rolling out a hot new generation of die-shrunk graphics chips. Cue a collective sigh on behalf of PC gamers across the globe.

Among the new chips are the bases of indisputably the fastest and most powerful graphics cards we've ever seen. Some of the numbers involved are spectacular, going on preposterous. Billions of transistors per chip, trillions of floating point operations per second, countless pixels pumped—it's all very exciting.

But along with a new performance paradigm has come a new pricing paradigm, from Nvidia at least. The Mean Green Graphics Machine has set a distinctly unwelcome standard in that regard with the $1,200 Titan X. That's one hell of a price for a 3D card. Even some of Nvidia's latest mid-range boards seem to be realigning the market at higher prices than before. Happily, that's just one half of the story. At the same time, AMD is making its play in exactly the opposite direction, with Polaris, an unambiguously and unashamedly value-oriented family of GPUs. The most expensive of the new Polaris-based Radeon cards rocks in at just $260. We won't see a new big-money hitter from AMD until at least the end of this year or, more likely, in early 2017.

In that sense, then, this new generation of graphics cards ought to have something for everyone. At the top end, there are new uber GPUs for those with money to burn. Lower down, there's the promise of more performance at lower prices than ever before.

The real test will be what all that means in practice. Has Nvidia, for instance, finally created a GPU capable of cranking out smooth 4K frame rates, no matter what you throw at it? Likewise, has AMD delivered on its promise of VR gaming at mainstream prices? Put simply, are these new graphics cards all they're cracked up to be? Has the wait been worth it? There's only one way to find out....

"STOP THAT, IT'S GETTING SILLY." That was our first reaction when Nvidia announced its new Titan X graphics board for $1,200. It's not that we're against high-end hardware—high-end hardware is what makes *Maximum PC* tick—but there's a limit to everything, and 1,200 bucks for a single rendering stick? Puh-lease. That's especially true when you take a closer look at what you're getting for your money with a Titan X. Indeed, our objections to Titan X's pricing arguably apply to other members of Nvidia's new Pascal graphics family. But that's getting ahead of ourselves. First, let's consider the context behind this new generation of boards.

More than any other generation, this one is all about those tiny nanoscopic suckers known as transistors. Or, more specifically, it's about the size of those transistors. Four and a half, long hard years, we've waited for the production process by which graphics chips are made to move on from 28nm. Yes, it was late 2011 when AMD launched the first 28nm graphics chip, the Radeon HD 7970.

In the meantime, Intel CPUs made the leap to 22nm, then 14nm transistors, almost in step with Moore's Law, which has long predicted that transistor density in computer chips doubles every couple of years. Things definitely didn't work out like that for a while in the PC gaming graphics industry. Part of that is down to the fact that just one Taiwanese outfit, TSMC, was responsible for manufacturing all of Nvidia's and AMD's high-performance GPUs. If TSMC stumbled, and it did after 28nm, the whole of PC gaming would be tripped up.

MOORE OR LESS

Thankfully, it seems like TSMC has got its act together again. It's basically skipping the 22nm node altogether, and jumping straight to 16nm, which almost puts graphics back on that Moore's Law track. Just for an added twist, however, Nvidia is sticking with TSMC and its new 16nm node for the new Pascal family of graphics, but AMD has made a bold leap into the relative unknown, and jumped ship to Global Foundries, and a brand new 14nm node.

We say "relative unknown" because Global Foundries was once part of AMD, and makes its CPUs and APUs. However, manufacturing complicated graphics chips is a whole different ballgame, and there Global Foundries has little to no track record.

That very likely explains why AMD has chosen to start its graphics production partnership with a family of compact, value-oriented graphics chips, rather than roll the dice on something bigger, beefier, and more likely to throw up manufacturing glitches. Suffice to say that this all adds up to an awful lot more than just a regular graphics refresh. There's some major action going on this year.

> “All are more expensive than the boards they replace, despite being based on smaller, cheaper GPUs.”

So far, Nvidia has been busiest. First, it cranked out its new performance boards, the GeForce GTX 1080 and 1070. They're a major step forward over Nvidia's Maxwell family. What's interesting is that it's arguably clock speeds rather than transistor count where Nvidia's new chips are doing the damage.

GIANT LEAPS

The GP104 chip inside the GTX 1080 and 1070 rocks in at just 7.2 billion transistors, which is modest when you consider the double node jump from 28nm to 16nm, and the fact that the old GTX 980 packed 5.2 billion transistors in its GM204 chip. It's not a huge surprise to find that the 1080 only has around 25 percent more CUDA cores than a 980. Instead, it's the big bump from 1,216MHz to 1,733MHz for the 1080's Boost clock speed that stands out. Imagine if Intel suddenly launched a CPU running at over 6GHz. That's the kind of leap Nvidia has delivered.

Nvidia has also wheeled out its mainstream gaming chipset, the GTX 1060. That's based on another new GPU: the GP106. With 1,280 CUDA cores, it's also a modest step over its progenitor, the GTX 960, with 1,024 CUDA cores. Again, Nvidia has cranked the Boost clock from 1,178MHz to 1,709MHz, which is where the performance gain lies.

Finally, we have the daddy of the new range, the Titan X. Nvidia's megachip follows a similar pattern—

AMD's beastly Fury X board will lumber on until 2017.

NVIDIA'S TITANS

Nvidia's new Titan X is the fastest gaming card the world has ever seen. But it's also the most expensive. So, what are these Titan boards about, and can the crazy prices possibly make sense?

Nvidia rolled out the first Titan in early 2013. This was the fastest graphics card a lot of money could buy. At $1,000, it was double the price of a GeForce GTX 680. However, the chip at the heart of the first Titan was GK110, a monster measuring 550mm^2, and it did more than just graphics. It was packed with features for general-purpose parallel computing, and formed the basis of Nvidia's high-performance Tesla compute boards. The follow-up Titan Black was just a fully enabled version of GK110, with all the CUDA cores switched on. However, Nvidia's approach shifted with the original Titan X last year. That used a new GM200 GPU from the Maxwell family, and ditched the fancy FP64 compute capabilities.

The latest Titan X is more of the same, only based on Nvidia's new 16nm Pascal architecture and a chip codenamed GP102. It's pure graphics, not an FP64 compute machine, even if Nvidia says it will be good at neural network computing, and won't be used for Nvidia's Tesla compute cards, which get their own P100 chip. It's also $1,200,

RADEON
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AMD

the new Titan X gets a modest uptick in functional units, but a major boost in operating frequencies.

The thing about all these new Nvidia GPUs is they're not very big. And size matters. Consider the new Titan X: At 471mm², its GP102 chip is much smaller than the 601mm² of the old Titan X. In fact, it's nearer to the GM104 chip in the GeForce GTX 980, which comes in at 398mm². The Pascal Titan X also has the same 12GB memory buffer as the old Maxwell edition. So why is it so expensive?

You could ask the same question about the new $600 GTX 1080 and, indeed, the $249 GTX 1060. All are more expensive in terms of launch price than the boards they replace, despite being based on smaller, cheaper GPUs. Enter, therefore, the alternative approach from AMD. Its new Polaris GPUs don't break any outright performance records, but they do claim to set new standards for gaming grunt at an affordable price.

The most expensive of AMD's new boards, the Radeon RX 480, is cheaper at $260 for the 8GB version than Nvidia's GTX 1060. The 4GB version is just $200. For that you get what AMD claims is a "premium VR gaming experience," the inference being that this new $200 board is good to go with the Oculus Rift or the HTC Vive. From there, the other members of the Polaris family that AMD has revealed, the RX 470 and RX 460, only get cheaper.

PERFORMANCE ART

In fact, the peculiar truth is that there is no overlap between Nvidia and AMD thus far with this new generation. It's not a straight fight at any price point. Instead, it's about measuring up the gaming reality against the claimed proposition. AMD's new boards need to deliver a level of performance never seen before at $200, and make cards from the previous generation look old, expensive, and pointless. As for Nvidia's new GPUs, they need to deliver a level of performance never seen before, period.

Nvidia's cheapest 1060 6GB still costs $249.

which sets a new high. Where the contradictions come in is that the new Titans are more graphics-focussed, so better value for gamers. On the other hand, the original Titan's exotic compute capabilities went some way to justifying the price, even though you were never going to use them.

With the latest Titan X, you're getting roughly 30 percent more performance for double the money of the GTX 1080, itself very expensive. That seems like a bum deal. Especially when you consider, based on our experience of the GTX 1080, that it might not quite even be the single-GPU 4K gaming solution the world has been waiting for.

Asus ROG Strix GTX 1080

All the bark, yet no bite

ASUS IS THE FIRST add-in-board (AIB) partner to use a fully autonomous manufacturing line. From start to finish, each and every card has zero human interaction. In short, it's meant to eliminate human error, reduce the amount of solder, and improve performance. Unfortunately, it doesn't take into account the greatest equalizer of them all: the silicon lottery. Our GeForce GTX 1080 Strix sample was, if we're honest, woeful. At its default "overclock" setting (configured in the new and improved GPU Tweak), it performed well, achieving a suitably comfortable overclock of 2,025MHz on the core clock. Unfortunately, it simply couldn't hold it for the duration of our testing session, and it continually crashed our *Ashes of the Singularity* benchmark run, even after a completely fresh install of Windows and its associated drivers.

The overclocking experience, which should be exceptional on a card like this, was equally frustrating. After 16 separate attempts to get the card to clock any higher than its overclock settings, we managed a not-so-impressive improvement of a meager 20MHz, and it still wasn't stable in the vast majority of our benchmarks. For a card at this price, and with Asus's legendary build and quality control, we expected more, and when our (admittedly most likely cherry-picked) reference sample GTX 1080 can outperform it by 113MHz, it just compounds the frustration.

That aside, it's possible we were just unlucky. It's still a quiet card—the fans won't spin up until the GPU is under load, and they never venture above and beyond 40 percent of total fan speed. The Strix sits at around 70 C under load, but that's well within operating parameters. Although the LED feature set isn't something we particularly care for here at *Maximum PC,* it's a nice feature to have for those looking to build a color-co-ordinated build, and performance is as solid as any other GTX 1080.

VERDICT 6

Asus ROG Strix GTX 1080

➕ **EAGLE** Quiet; stylish design; GTX 1080 performance.

➖ **SEAGULL** Crashes in OC mode; poor overclocking; chip-dependent; pricey.

$710, www.asus.com

MSI GeForce GTX 1070 Gaming X 8G

The ideal aftermarket card

NOT TO KEEP DIGGING on the Asus Strix on the left, but MSI's GeForce GTX 1070 Gaming X truly nails it when it comes to what we expect from a premium grade aftermarket card. OK, it does follow MSI's ridiculously long-winded naming scheme (seriously, who thinks these things up?), but we all remember the old saying: It's not the size of the name that matters, but how it performs. And that's exactly what the MSI Geforce GTX 1070 Gaming X 8G does. The GP104 at its core is no whiny slacker, hitting performance comparable to a Maxwell Titan X, yet at less than half the cost. This beauty nails 1440p into the floor, scoring well into the sixties for most AAA titles, taking the legacy of the GTX 970 and dragging it by its ankles all the way into the 1440p era.

That said, the Gaming X is still as well rounded as ever. MSI has improved its Twin Frozr cooling design (now in its sixth generation), enhancing both the thermal performance and noise control. Couple that aforementioned performance with sleek aesthetics and a cool, quiet design, and you're left with a card that would most definitely be an impressive little addition for any system.

Overclocking was truly joyous. Through MSI's Gaming X app, you have access to three separate profiles, depending on your preference, each with set fan curves responding to the variances in temperature provided by the additional voltages and higher clock speeds. What is nice is that MSI has gone to the trouble of also overclocking the memory frequency in its highest overclock profile, and has still managed to retain stable performance. All profiles aside, we managed to get a manual final clock speed of 2,100MHz—50MHz higher than our cherry-picked reference sample.

The Gaming X is solid: It performs well, overclocks like a champ, is sleek and quiet, and combined with the GTX 1070, nails what is arguably the sweet spot of PC gaming right now—1440p.

VERDICT 9

MSI GeForce GTX 1070 Gaming X 8G

➕ **PC GAMING** Great AIB card; strong overclocker; solid software suite; perfect for 1440p.

➖ **MOBILE GAMING** RGB lighting on red card.

$450, www.msi.com

AMD Radeon R9 Nano

It's not the size of your boat...

ONE OF THE BEST THINGS about HBM is how little space it takes up on the PCB, in lieu of traditional GDDR5 and 5X memory stacks. Thanks to being able to stack it vertically, as opposed to horizontally next to one another, you can shore up a lot of extra space on the PCB. And, of course, if there is excess space, it's possible to eliminate that space entirely. Thus, here we are, with the R9 Nano. It houses the exact same Fiji graphics processor and 4GB of HBM as the Fury X, but—alas—that's where the similarities end. The Nano is composed of a six-inch form factor, a single eight-pin power, and a core clocked slightly lower at 1,000MHz, as opposed to the Fury X's 1,050MHz.

But is that shrink in size enough to warrant the extra cost? Overall graphics performance is exceptional, especially for a card with dimensions like this. At 1080p, average frame rates of 60–70fps is common. At 1440p, graphics performance does falter a touch, with averages dropping down to 45 frames per second, but it's still a thoroughly enjoyable experience in AAA titles. However, in contrast to the full might of the Fury X, it does lack substance. There's a 10–12 percent difference in performance, and when you consider that the Nano currently costs more than AMD's flagship by almost $70, you have to ask who exactly is this card for? After all, although it's only six inches wide, it's still a full-height card, it still utilizes a single eight-pin PCIe power, and it still draws almost as much power from the wall as a Fury X.

What the Nano does show us is just how important core clock speed is to the Fiji XT processor. But where does the Nano fit exactly? There's no doubt that its overall footprint is far smaller than anything we've seen, but it's just not small enough. It's quiet, but it lacks cooling potential, and it performs well at 1080 and 1440p, but lacks the confidence that the Fury X provides with higher performance.

VERDICT **7**

AMD Radeon R9 Nano

+ NANITES Smallish form factor; solid 1080 and 1440p performance.

– JUST NAHH... Performance drop compared to Fury; full-height card.

$470, www.amd.com

Nvidia GeForce GTX 980

An ageing giant?

ARGUABLY, THE GEFORCE GTX 980 is the king of computer graphics. Although not the first sighting of Nvidia's almost legendary Maxwell architecture, the GTX 980 capitalized on the new and improved GM204 processor. With 4GB of GDDR5, 5.2 billion transistors, and a 256-bit bus, the GTX 980 proved that it was the master of overclocking, and a flagship card of its time—at least, until the Titan X and GTX 980 Ti launched later, of course.

Does it still hold up? Sort of—you have to value it at its current price to truly appreciate it. And although the likes of the GTX 1060 now match it, almost like for like, when it comes to performance, it's still worth taking into consideration—if you can find it. It decimates 1080p, absolutely demolishing average frame rates left, right, and center without worry. It's not uncommon to see it average well into the sixties for most AAA titles. Couple that with its potential to overclock by a good 260MHz or so on the core clock, and nearly 450MHz again on the memory, and it's a card not to be underestimated.

The reference variant, although exceptionally rare on the scene now, is cool, quiet, and stylish. There's no controversially outlandish strange-shaped triangles littering the shroud here, just that tried-and-true blower fan setup with which we first fell in love at the launch of the original Titan, way back when. It does the job exceptionally well, in fact—especially in more cramped cases and conditions. ITX cases, in particular, fare well with this mighty behemoth.

So, what is it that still makes the GTX 980 such an appealing proposition? Especially with the likes of the GTX 1060 looming on the horizon? Three letters: SLI. Although it's not for everyone, for those looking to upgrade today, and who already own a GTX 980, getting an additional one will add performance in abundance, and save you from having to spend your hard-earned cash on a GTX 1070 or above, for anywhere near a decent increase in performance figures.

VERDICT **7**

Nvidia GeForce GTX 980

+ THE KING Impressive 1080p performance; incredible overclocker; SLI.

– THE THING Still a little pricey new; not technically an upgrade.

$440, www.nvidia.com

XFX AMD R9 Fury X

Still Team Red's top end

BOY, WOULD IT BE NICE to see a high-end card from AMD right now, huh? The Fury X certainly feels like it's lagging a bit, especially with the likes of the GTX 1080, and now the Titan X, throwing themselves into the battle for GPU domination. But, for bang for buck, it's still an exceptional card. Right now, you can purchase an old-school water-cooled Fury X for less than $400, making it cheaper than the cheapest GTX 980 or 980 Ti, a card it fought with for superiority.

It's an ambitious move on AMD's part, but that's what the Fiji core at the heart of the Fury X has always been about. With a leap into high-bandwidth memory, an innovative step forward in reference cooler design, and the ambition to place it on not one but three separate styles of card, each with a different purpose, it was certainly ballsy. Did it pay off? Well, not quite, but you have to admire its gusto.

As a performer, the Fury X is staggering for its size and limited VRAM. At 1440p, it dominates, easily securing 60 frames per second in most AAA titles. In fact, it's not too far off the performance of a GTX 1070. Where the Fury X really comes unstuck is 4K gaming and overclocking. Although HBM's colossal memory bandwidth does help to alleviate some of the bottleneck at higher resolutions, it just doesn't have enough grunt in the core to really push the frame rates at the top end. On top of that, overclocking might as well not exist. It's a sordid affair—at most, we managed to add another 75MHz on the core clock, and 25MHz on the memory clock, certainly not enough to write home about. The volatility of the programs used, and AMD's lack of support for overvolting, leave much to be desired.

For the money, its similar performance as the GTX 980 Ti and GTX 1070 makes this card an appetizing offer. 1440p performance is exceptional, and the overall styling is really something else—a genuine innovation on AMD's part.

VERDICT

8

XFX AMD R9 Fury X

⊞ **FURIOSA** Staggering 1440p performance; great value for money; cool.

⊟ **FURIOUS FIVE** Coil whine; no overclocking headroom; struggles at 4K.

$400, www.amd.com

Zotac GeForce GTX 1060 AMP! Edition

RX 480 versus GTX 1060. Fight!

WE'VE SAID IT OFTEN ENOUGH: It's never about the flagships. Yes, a lot of people—ourselves included, to be honest—would happily go out and buy the GTX 1080 and future RX 490s of this world. However, the vast majority of investment and profit in this industry is actually made in the mid-range, with the GTX 1060s and RX 480s. The 1060 is a direct response to the launch of AMD's exceptionally aggressively priced RX 480. Team Red's card came in positioned snugly between both the GTX 980 and 970, and at a price point that would make most of the previous generation's card buyers weep. And with it, Nvidia announced the launch of the GTX 1060, a card designed to provide GTX 980 performance on a budget. Well, sort of—the Founder's Edition reared its ugly head first, demanding a $50 price premium for just two weeks' early access, along with a slightly shiny reference cooler.

Let's be honest, though, that's not what's interesting here. It's the AIB partner cards that arouse our curiosity. This wee beauty, for instance, secures performance at 1080p, and provides an acceptable 40–50fps in AAA titles at 1440p, as well. Like for like, the performance is almost identical to that last-generation flagship. It even has the legendary Maxwell-esque overclocking capacity, too. We managed to push ours up 240MHz on the core alone, improving Fire Strike scores by well over a thousand. It's a small card, sleek and quiet, with 0dB fan technology enabled to keep your desktop experience comfortable, at an aggressively priced $350. The only downside? No SLI support for those looking to boost their performance in a year or two's time.

All in all, the GTX 1060 really has come of age at this point. With aftermarket variants coming in at ever lower prices, and a 3GB version on the horizon for those looking solely at 1080p gaming, it looks as though Nvidia really has this one in the bag—or, at least, its AIB partners do.

VERDICT

9

Zotac GeForce GTX 1060 AMP! Edition

⊞ **AMPLIFIED** GTX 980-like performance; exceptional value; cool and quiet; 0dB fan tech; OC crazy.

⊟ **AMPUTATED** No SLI support.

$290, www.zotac.com

Gigabyte GeForce GTX 970 Windforce 3X

Super-cool value still viable?

THE GEFORCE GTX 970 was our most recommended graphics card of last year. In fact, you'd be hard pushed to find a tech journalist who wasn't suggesting you buy this for a fresh system. For 1080p gaming, it was the sweet spot of the time. 3.5GB of VRAM aside, it consistently provided solid performance in AAA titles at 60 frames per second, and for an incredibly reasonable price. Combine that with Nvidia's aggressive marketing of both G-Sync and GeForce Experience, and it was a shoo-in for Team Green earning a healthy chunk of the mid-range market share.

Times have changed, however. The likes of the GTX 1060 and the RX 480 are on the scene now, so can this ageing hero keep up with the new generation of more powerful, more efficient youngsters? In a word, perhaps. It depends on the manufacturer and make. Take this Gigabyte Windforce card: It's a triple fan cooled, high overclock variant of the reference GTX 970. It comes with a high base boost clock reaching up to 1,278MHz in its overclocked mode—a full 100MHz higher than the stock card—and performs damn near close to the reference GTX 980, at least at 1080p, scoring in the mid-50s in both *Far Cry Primal* and *The Division.*

Crank up the overclock, and you can easily hit a final core clock of 1,500MHz. We managed 1,529MHz as our final boost, in fact, a whole 4MHz higher than our reference GTX 980. Winning is winning here, and that's damn impressive for what should otherwise be a crippled core. Even at stock, that led to a 1,200 point increase in Fire Strike, and around a 10 percent increase overall in our other titles, or the equivalent of swapping from a Intel Core i7-6700K to a 6950X.

At the time of writing, this little beauty is available for $280, putting it just above an AMD RX 480 in price. Is it worth buying now? Probably not, but the old girl's still got some life in her yet, and if you're not quite ready to give her up, it might be worth considering SLI.

VERDICT
7

Gigabyte GeForce GTX 970 Windforce 3X

⊞ **HURRICANE** Astonishing overclock; solid 1080p performance; cool and quiet.

⊟ **LIGHT BREEZE** Long card; still a touch pricey; 3.5GB of effective VRAM.

$280, www.gigabyte.com

AMD Radeon RX 480 8GB

AMD strikes back

THIS IS THE YEAR of the sub-16nm transistor. The year of manufacturing processes transcending the limitations of 28 nanometers. Nowhere has this achievement been seen more clearly than on AMD's Polaris architecture, GCN 4.0, the latest and greatest addition to AMD's arsenal. Designed to accentuate the very best gaming experiences, at the very best performance-per-watt, it's a generational jump beyond anything we've seen in the last 15 years.

The AMD RX 480 is at the very forefront of this technological standard, with its brothers the RX 470 and 460 very close behind. It's a killer deal—with performance sitting eagerly between both the GTX 970 and 980, it nails that 1080p 60 frames per second sweet spot that we all love, without so much as a hiccup. And at a price as low as $260 if you shop around, it's insanely difficult to compete with this card, or even recommend an alternative.

Of course, we have to address the power draw issue at launch. It plagued the cards and worried consumers across the grid, because it was drawing too much power through the PCIe slot, consistently above the recommended spec set out by PCI-SIG (ironically, the same organization that approved this card in the first place). It has since been fixed through a compatibility mode implemented in AMD's Crimson settings suite, but unless you're running three or more of these cards on a motherboard that's more than five years old, you have very little to worry about. That said, if you do opt for the compatibility mode, you'll notice frame rates around half a frame slower than when it was first launched—pretty snazzy, in our opinion.

So, it's a cool, quiet card, it nails 1080p gaming on the head, overclocks reasonably well, comes in both 4GB and 8GB variants, has CrossFire for expandability down the line, and is available (at the time of writing) for around $260. Need we say more?

VERDICT
8

AMD Radeon RX 480 8GB

⊞ **RADICAL** Strong 1080p performance; good value; has CrossFire; power draw abated; fair overclocker.

⊟ **REPUGNANT** Power issues at launch.

$260, www.amd.com

AMD Radeon RX 480 4GB

Who needs 8GB?

10-BIT COLOR COMPRESSION: that's what you have to thank for AMD and Nvidia retaining the 192-bit and 256-bit bus memory bandwidths. Both these manufacturers use exceptional color compression to ensure that the memory bus never saturates when transferring high-resolution textures across to the GPU. It makes a difference—a huge one—as you'll soon see.

AMD's RX 480 comes in two variants: 4GB and 8GB. Apart from that and the price, there's no difference between the two cards. Who would be mad enough to buy the 4GB version, though—right, guys? After all, we need that 8GB frame buffer, especially with the graphical fidelity of most AAA titles today. Well, maybe not. While testing the 4GB RX 480, we were blown away by the difference between these two mid-range budget behemoths. Or should we say, lack of difference? All the way from 1080p to 4K, both average and minimum frame rates fluctuated by no more than one or two frames per second. Staggering. Absolutely staggering.

That aside, it's still essentially the same card. You still get the same Polaris 10 core at its heart, the same memory bandwidth, the same number of shaders, and all the goodies associated with GCN 4.0. It's cool, quiet, and can be overclocked by a good 6–8 percent, depending on your luck with the silicon lottery, bringing it well in line with the GTX 980 in terms of performance, for a little less than 200 bucks.

Right now, you can pick up an RX 480 8GB for $260—a good $60 more than the 4GB variety. And what do you get for it? A performance increase of almost nothing. In fact, you lose money when it comes to frames per dollar. What's impressive about that is that the 8GB RX 480 was already astonishingly good value. It toppled last gen's titan of industry, the GTX 970, and the reality is that it's still good value. But compared to the 4GB RX 480? Nothing compares. If you're after a cheap, powerful, 1080p gaming system, the RX 480 4GB is the way to go.

VERDICT
9
KICK ASS!

AMD Radeon RX 480 4GB

⊞ **REDEEMER** Phenomenal value; solid overclocking potential; cool and quiet; strong 1080p performance.

⊟ **RESCINDED** AIB cards will clock higher.

$200, www.amd.com

MSI Radeon RX 470 Gaming X 8G

Nailing the mid-range

WHAT A TIME TO BE ALIVE! What a generational jump for graphics card owners. The difference between those old 28nm processors and today's 14 and 16nm cores is absolutely incredible. Take a look at this card here. Like for like, it's treading toe to toe with the GTX 970. What was at launch a $350 graphics card has now been ousted by a card that comes in at $150 cheaper. It's remarkable really.

MSI's Radeon RX 470 is an overclocked model of AMD's low-end mid-range GPU. It still requires an eight-pin PCIe power, and still has 8GB of VRAM on board, making it quite comparable to the RX 480 in a lot of ways. And overall performance figures aren't far off, either—no doubt due in part to that hefty 48MHz overclock on the core. But that leads us to a good question: Why would you consider buying this over something such as a 4GB RX 480? As we've already seen, the 4GB version of the 480 is more than capable of holding its own at stock, and considering that these two cards come in at the same price point—yet this one comes pre-overclocked and the 480 doesn't—we can't quite work out who this card is aimed at.

OK, perhaps you're not bothered about learning, or aren't interested in the minor risk factors or time investment that's associated with finding a stable overclock on a card. But even so, by pressing one of those three profiles situated in MSI's Gaming X app, you're essentially doing nothing different from loading an overclocked profile. You still run the same risks.

What is nice here is that MSI has included its full-sized RGB cooler that's found on its other cards. The Twin Frozr VI keeps the card cool and exceptionally quiet, and even provides a little extra headroom if you do want to push the RX 470 just that fraction higher. Performance-wise, it's still averaging well into the fifties at 1080p, and forties at 1440p, and it's an absolutely solid card, scuppered only by the phenomenal value of its rival, the 4GB RX 480.

VERDICT
9

MSI Radeon RX 470 Gaming X 8G

⊞ **RADIANT** Strong performance; super cool and quiet; great overclocker; plug and play.

⊟ **ROTTEN** Doesn't quite beat the 4GB RX 480.

$200, www.msi.com

HOW WE TESTED

All the cards were tested at three resolutions, measuring minimum and average frame rates. Our test bed consists of an Intel Core i7-6700K, 16GB of Crucial Ballistix Elite DDR4 @ 2,666MT/s, a Samsung 850 Evo 500GB, and an 850 Pro 2TB SSD, on Windows 10 Technical Preview. *Ashes of the Singularity* does not run at 4K with AMD cards on Windows 10 Technical Preview, thus the "DNC" results. Thus, our 14-game average frame rate calculations exclude this 4K result for all cards. We also find the max overclock on each card, and benchmark again in 3DMark's Fire Strike and Time Spy. We don't have space to provide results here, but they're often referred to in the reviews.

SPECIFICATIONS

	GPU	Lithography	Cores	Memory	Memory Bus	Power Draw	14-Game Average	Price Per FPS
Asus ROG Strix GTX 1080	GP 104	16nm	2,560	8GB GDDR5X	256-bit	49W/325W	59fps	$12.03
MSI GTX 1070 Gaming X 8G	GP 104	16nm	1,920	8GB GDDR5	256-bit	53W/306W	49fps	$9.18
AMD Radeon R9 Nano	Fiji XT	28nm	4,096	4GB HBM	4,096-bit	60W/311W	37fps	$12.70
Nvidia GeForce GTX 980	GM 204	28nm	2,048	4GB GDDR5	256-bit	58W/237W	34fps	$12.94
XFX AMD R9 Fury X	Fiji XT	28nm	4,096	4GB HBM	4,096-bit	62W/330W	42fps	$9.52
Zotac GTX 1060 AMP! Edition	GP 106	16nm	1,280	6GB GDDR5	192-bit	52W/257W	35fps	$8.29
Gigabyte GTX 970 Windforce 3X	GM 204	28nm	1,664	4GB GDDR5	224+32-bit	56W/251W	30fps	$9.33
AMD Radeon RX 480 8GB	Polaris 10	14nm	2,304	8GB GDDR5	256-bit	59W/303W	32fps	$8.13
AMD Radeon RX 480 4GB	Polaris 10	14nm	2,304	4GB GDDR5	256-bit	58W/281W	31fps	$6.45
MSI Radeon RX 470 Gaming X 8G	Polaris 11	14nm	2,048	8GB GDDR5	256-bit	58W/285W	29fps	$6.90

1920X1080 BENCHMARKS (1080P)

	Total War: Attila	Far Cry Primal	The Division	Rise of the Tomb Raider	Ashes of the Singularity	3DMark Fire Strike
Asus ROG Strix GTX 1080	46/58	86/111	65/104	38/71	41/61	17,704
MSI GTX 1070 Gaming X 8G	38/52	74/92	56/87	30/56	31/52	15,440
AMD Radeon R9 Nano	26/35	56/71	38/66	11/38	31/46	12,223
Nvidia GeForce GTX 980	28/40	51/65	29/59	15/41	24/38	11,338
XFX AMD R9 Fury X	31/43	59/76	42/72	9/42	34/55	13,888
Zotac GTX 1060 AMP! Edition	26/38	53/66	31/60	15/38	19/36	10,959
Gigabyte GTX 970 Windforce 3X	24/35	45/57	33/55	12/36	21/31	10,313
AMD Radeon RX 480 8GB	21/30	48/61	34/58	11/34	23/36	10,542
AMD Radeon RX 480 4GB	23/30	46/58	32/58	8/33	22/29	10,582
MSI Radeon RX 470 Gaming X 8G	21/28	44/54	36/55	9/31	25/34	10,135

2560X1440 BENCHMARKS (1440P)

	Total War: Attila	Far Cry Primal	The Division	Rise of the Tomb Raider	Ashes of the Singularity	3DMark Fire Strike
Asus ROG Strix GTX 1080	21/42	68/80	41/75	17/45	28/51	9,958
MSI GTX 1070 Gaming X 8G	23/36	55/65	47/63	14/35	25/44	8,221
AMD Radeon R9 Nano	16/23	43/52	26/49	6/23	22/36	6,323
Nvidia GeForce GTX 980	14/23	38/45	25/43	8/24	26/30	5,822
XFX AMD R9 Fury X	20/27	47/57	30/55	7/25	27/45	7,248
Zotac GTX 1060 AMP! Edition	14/25	39/46	20/43	16/28	19/31	5,835
Gigabyte GTX 970 Windforce 3X	10/20	34/41	20/35	4/17	19/27	5,366
AMD Radeon RX 480 8GB	13/19	35/43	27/42	8/22	20/30	5,205
AMD Radeon RX 480 4GB	13/19	35/41	24/42	7/20	22/29	5,232
MSI Radeon RX 470 Gaming X 8G	11/17	32/38	20/39	7/19	20/28	5,028

3840X2160 BENCHMARKS (4K)

	Total War: Attila	Far Cry Primal	The Division	Rise of the Tomb Raider	Ashes of the Singularity	3DMark Fire Strike
Asus ROG Strix GTX 1080	9/20	40/44	21/43	8/22	30/43	5,339
MSI GTX 1070 Gaming X 8G	9/17	32/35	17/35	7/17	23/35	4,499
AMD Radeon R9 Nano	6/11	25/29	14/29	3/9	DNC	3,366
Nvidia GeForce GTX 980	6/11	21/23	13/25	3/8	16/24	3,132
XFX AMD R9 Fury X	9/14	29/34	20/34	4/9	DNC	3,922
Zotac GTX 1060 AMP! Edition	4/12	22/24	13/24	8/13	18/25	3,002
Gigabyte GTX 970 Windforce 3X	6/10	18/21	11/23	3/6	13/21	2,808
AMD Radeon RX 480 8GB	5/9	21/24	12/24	4/10	DNC	2,725
AMD Radeon RX 480 4GB	5/8	17/22	11/24	4/8	DNC	2,772
MSI Radeon RX 470 Gaming X 8G	2/8	15/21	12/22	4/8	DNC	2,657

RADEON
RADEON
AMD

And the winner is...

AMD Radeon RX 480 4GB

WHY IS IT SO HARD to discern a winner with these supertests? As *Maximum PC* has matured, we've realized there's never going to be an absolute winner. There can't be. As in real life, it all depends on your circumstances. For instance, if you already have a 4K gaming setup, upgrading to our recommended 4GB RX 480 isn't going to cut it. You're going to have to take that hit when it comes to value per frame. But you will, and rightly so, because the gaming experience beyond 1080p is exceptionally enjoyable, especially at higher refresh rates.

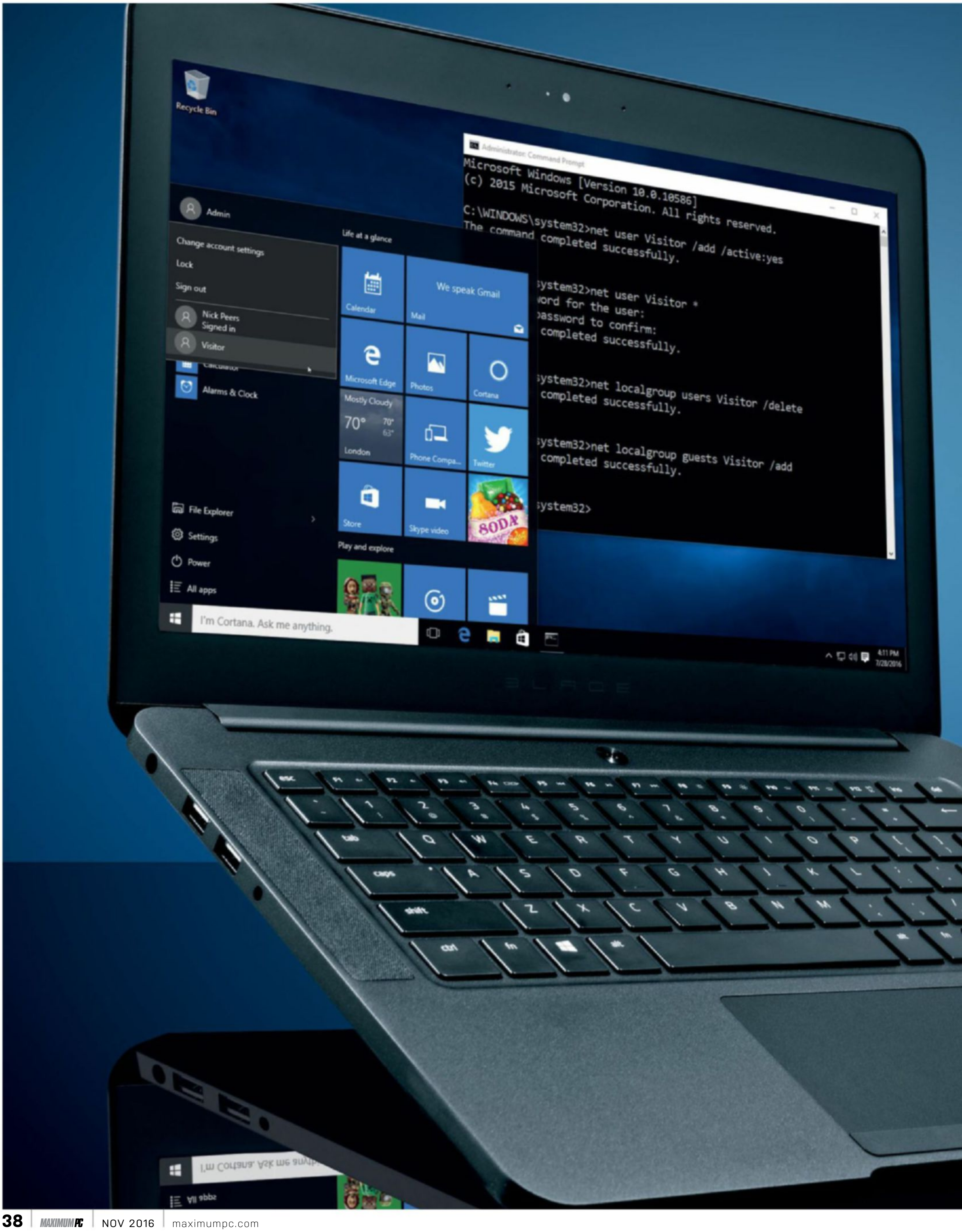
However, we have to look at the bigger picture. We have to ask, who would benefit the most from an upgrade, and what should that upgrade be? After all, fewer than five percent of PC gamers play above 1920x1080, which means it's pretty simple to answer that question. The Radeon RX 480 4GB model is the best card that you can purchase today by far. Value for money, it's second to none. Packing the potential for GTX 980 performance in a card that costs as little as $200 is insane. It doesn't break the bank, but nor does it break frame rate limits or revolutionize the industry—but that doesn't stop it from being an exceptional card. Although there were power draw issues at launch, they were mostly associated with the 8GB variant (and, as you can see from our tests, the 4GB draws far less from the wall, outside of compatibility mode), and they have been resolved for everyone still concerned about the longevity of their motherboards. The reference model does leave a little to be desired—aftermarket variants will most definitely perform better and be quieter at higher fan RPMs—but you're still not going to be disappointed, even with the reference version.

That's not to say Team Green should be left out in the cold, however. The continuous push for higher performance through the Pascal architecture is nothing short of incredible. What we can achieve today with the GTX 1080 GPU is astronomical—we've never seen frame rates or clock speeds higher. And although the price jump has been a little unwieldy, it's an incredible leap in performance. With a little cautiousness over your in-game settings, it's easy to achieve 60fps at 4K with this card (seriously, take a look at antialiasing settings at 4K—you'll understand what we mean after you do a bit of experimenting).

THE 4K FUTURE

All in all, if this is any indication of what we can expect over the next few years, it's a beautiful time to be alive for a gaming enthusiast. Both Pascal and Polaris are just the first steps in a rapid advancement toward increased frame rates and bringing the 4K dream to life, making it a reality on screen, at an affordable price point. Yes, there's always going to be something better—no doubt we'll start seeing 5K, even 8K, displays, with high refresh and HDR, coming down the pipeline for the super rich—but for the majority of us, it's going to be an easy step up to the resolutions of the future, and a fond farewell to the HD screens that have brought us this far.

In short, if you're after the best upgrade, and you haven't bought a graphics card since the era of the GTX 680, AMD's RX 480 4GB is the way to go. If you're looking for the absolute top-end in performance, grab yourself a solid aftermarket GTX 1080, perhaps two (we wouldn't recommend the new Titan X at this point, as it's more of a developer card, and hammers that frame-per-dollar score into the ground). If you're after a high-end upgrade, but you still want to hold on to the value aspect, the best card around today is MSI's overclocked GTX 1070 Gaming X. Just remember, take into consideration your resolution, your refresh rates, and what games you play when making your decision, and you can't go wrong.



Recycle Bin
Administrator: Command Prompt
Admin
Change account settings
Lock
Sign out
Nick Peers
Signed in
Visitor
Calculator
Alarms & Clock
File Explorer
Settings
Power
All apps
Life at a glance
Calendar
We speak Gmail
Mail
Microsoft Edge
Photos
Cortana
Mostly Cloudy
70°
70°
63°
London
Phone Compa...
Twitter
Store
Skype video
SODA
Play and explore
I'm Cortana. Ask me anything.
4:11 PM
7/28/2016

```
Microsoft Windows [Version 10.0.10586]
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C:\WINDOWS\system32>net user Visitor /add /active:yes
The command completed successfully.


system32>net user Visitor *
word for the user:
password to confirm:
 completed successfully.

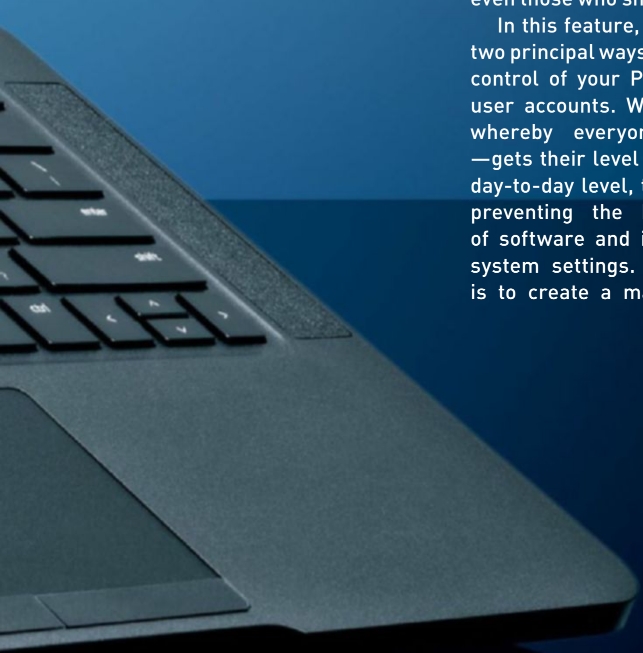

system32>net localgroup users Visitor /delete
 completed successfully.


system32>net localgroup guests Visitor /add
 completed successfully.


system32>
```

RECLAIM OWNERSHIP OF YOUR PC

Discover how to take back control of Windows, with help from *Nick Peers*



Ever felt you're losing control of your PC? If you share it with other users—family members or friends, for example—it can be a frustrating experience. First, there's the need to keep your own data private from other people, then there's the worry about what they might be doing behind your back. Windows has tools for managing children's use, but what happens to a PC that's shared between a group of consenting adults—even those who should know better?

In this feature, we're going to examine two principal ways in which you can regain control of your PC. The first is through user accounts. We'll reveal a technique whereby everyone—including yourself—gets their level of access reduced on a day-to-day level, tightening security, and preventing the haphazard installation of software and injudicious tweaking of system settings. The secret to this tip is to create a master Admin account—password-protected, of course—which is required whenever any elevated access (including the installation of many programs) is required.

We'll also look at a tool those running Windows 10 Professional can employ in conjunction with user accounts—namely the Local Group Policy Editor—to tighten things further, giving you complete control over restrictions on a user-by-user basis. We'll show you how to restore the Guest account that Microsoft has mysteriously dropped in Windows 10, too.

Then we'll examine how you can control access to individual files and folders through permissions—after reminding you to take precautions, we'll delve into how you can make people's folders private, while blocking their access to other parts of your system (including individual programs, if required). There's even time for troubleshooting file permissions issues (both those caused by your fiddling and those created by Windows itself), finding out the best way to transfer to a new PC, and integrating your OneDrive storage better into your user folders. The end result? A PC that may be shared with others, but which remains your own, is under more control and better secured.

Let's open with something that might seem counter-intuitive: Step one to reclaiming ownership of your PC is to reduce your level of access to it. Yes, you heard right—one of the most effective ways in which you can secure control of your PC is to downgrade your user account to that of a Standard User.

Why would you do this? First, it reduces your PC's exposure to potential harm—now, instead of simply waving through requests for elevated access with a simple click of the mouse, you need to invoke a separate Administrator account (and password) instead. The inconvenience of doing so is outweighed by the fact that it forces you to pause and confirm what the dialog is there for—no more lazily waving through something malicious by mistake.

It's also essential if you share your PC with others—by downgrading everyone, they're forced to either use the Admin password (if you've shared it with them), or ask your permission before cluttering up your PC with more unwanted software.

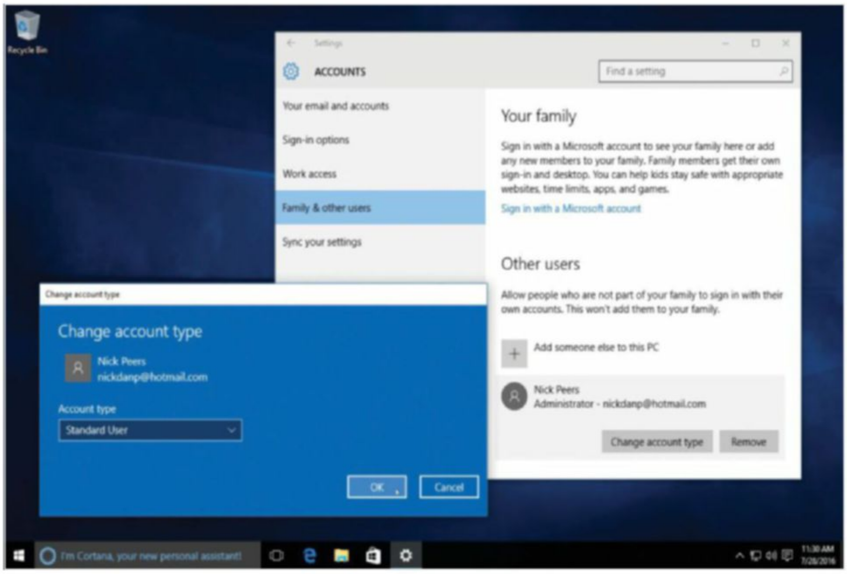
The first step of this process involves creating a new Administrator account—click "Start → Settings → Accounts → Family & other users," then click "Add someone else to this PC" under "Other users." Choose "I don't have this person's sign-in information," followed by "Add a user without a Microsoft account." Name the account "Admin," then enter a secure password, before clicking "Next."

With the account set up, you next need to make it an Administrator account—select the account under "Other users," and click "Change account type" to convert it to Administrator. You're now ready to log off your own account and change it. Before doing so, consider switching yourself to a Microsoft Account, if you haven't already done so. It makes installing apps from the Microsoft Store easier, for starters—they're sandboxed to your local account folder, so don't require elevated privileges.

Sign out of your account, and log in as Admin (wait while the account is first set up). Return to the "Family & other users" screen, where you'll see your own account listed. Select this, click "Change account type," then reduce it to Standard user. Repeat for all other users of your PC.

Now, when you have to perform any administrative tasks, you're prompted to select an Administrator account ("Admin" should be pre-selected by default), and enter its password to proceed. You can make this step a bit easier by assigning a more memorable PIN number, and entering that instead—do this now via the "Sign-in options" screen (click "Add" under "PIN").

Once done, sign out of Admin, and log back into your own account. For additional



Your family

Sign in with a Microsoft account to see your family here or add any new members to your family. Family members get their own sign-in and desktop. You can help kids stay safe with appropriate websites, time limits, apps, and games.

Sign in with a Microsoft account

Other users

Allow people who are not part of your family to sign in with their own accounts. This won't add them to your family.

Add someone else to this PC

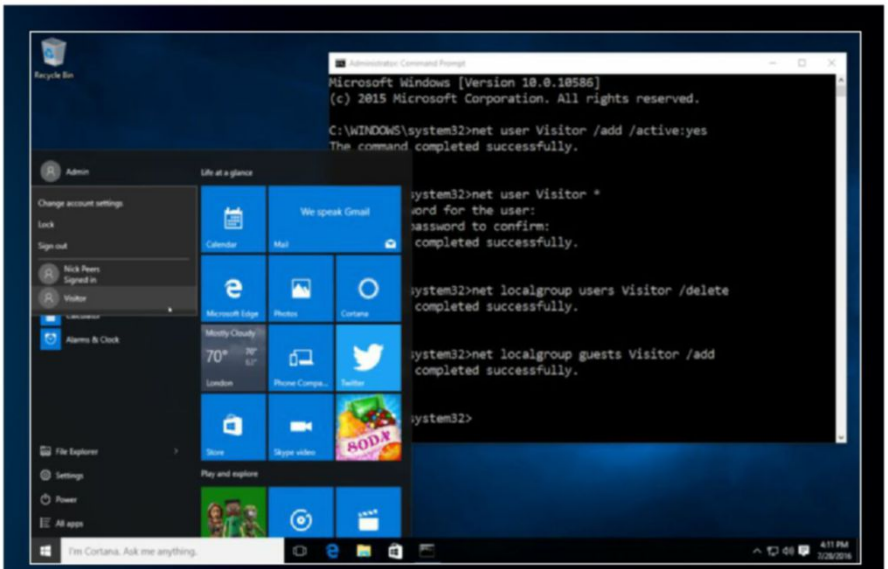
Nick Peers
Administrator - nickdanp@hotmail.com

Change account type

Nick Peers
nickdanp@hotmail.com

Account type: Standard User

Downgrade all users (including yourself) to Standard User level.



```
Microsoft Windows [Version 10.0.10586]
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C:\WINDOWS\system32>net user Visitor /add /active:yes
The command completed successfully.

ystem32>net user Visitor *
ord for the user:
assword to confirm:
 completed successfully.

ystem32>net localgroup users Visitor /delete
 completed successfully.

ystem32>net localgroup guests Visitor /add
 completed successfully.

ystem32>
```

Set up a Guest Account

If you frequently have fleeting visitors in your home, you may wish to provide a limited user experience for basic tasks such as browsing the web. For reasons unknown to us, Microsoft has disabled the Guest account, but it's relatively straightforward to get back, and the quickest way is via the Command Prompt. To create a guest account named Visitor, and assign it to the Guest account group, first right-click the "Start" button, choose "Command Prompt (Admin)," then type the following:

```
$ net user Visitor /add /active:yes
$ net user Visitor *
```

Press [Enter] twice when prompted to add a password, so it stays blank. Now type:

```
$ net localgroup users Visitor /delete
$ net localgroup guests Visitor /add
```

The first command removes the Visitor account group (all new accounts are allocated their own group of the same name), while the second then assigns it to the Guest group. Yes, despite the fact that Microsoft has removed the Guest account, it has kept the Guest group alive, which basically offers exactly the same level of limited accessibility as the Guest account provided in earlier versions of Windows.

Once complete, your guests can be directed to the Visitor account. They can use a limited set of apps, but will be denied access to other parts of your system, such as Settings and the Microsoft Store. You can still install desktop programs, however—with the requisite Admin password and/or PIN, of course.

security, type "UAC" into the Search box, and click "Change User Account Control Settings"—you'll see your first security prompt, requiring you to enter your Admin password or PIN. Verify the slider has been set to the top level.

One of the most visible ways in which your access has been downgraded is seen when you open the Settings app—it's now less functional than it was before, because all system-wide settings are now off limits. To get at them requires logging into the Admin account directly (do this quickly via the Start menu—click your user picture at the top of the menu, and select "Admin" to switch user without logging out). Or does it? In fact, most system-wide settings remain accessible via the classic Control Panel—just enter your Admin password to access them when prompted.

Use Group Policy settings

If you're running Windows 10 Professional, you can set further restrictions on a user-by-user basis using the Local Group Policy Editor—launch gpedit.msc to take a tour. It's a little baffling for first-time users, so take the time to explore its settings, and make sure you take a drive image before you begin—it's very easy to lock yourself out of your system. Most Group Policy settings are basically Registry edits, and if you're running Windows 10 Home Edition, you can emulate most of these with the correct setting. Thankfully, Microsoft has provided a handy reference guide containing each policy's setting and its equivalent Registry entry—go to www.microsoft.com/en-us/download/details.aspx?id=25250, and select "Windows 10 ADMX spreadsheet.xlsx" when prompted.

By default, gpedit.msc shows the Local Computer Policy settings, which means the settings are applied across your entire PC. For a more granular approach, involving a single user or group, you need to apply a customized Local Group Policy instead. Press Win-R, type "mmc," and hit Enter. Choose "File → Add/Remove Snap-in." Select "Group Policy Object Editor" from the left-hand pane, and hit "Add." Click the "Browse" button, and select the "Users" tab. Choose your target user (yourself, say) or group ("Non-Administrators," for example), and then click "OK → Finish → OK." Now choose "File → Save" to save a copy somewhere accessible (going forward, you would double-click this file to view and edit it).

With the template in place, you can now start to customize settings or restrict access. The Administrative Templates section is a good first port of call. Select a section, then click on a setting in the right-hand pane to read a description of what it does. Double-click it to make a change—this usually means enabling or disabling the policy, but sometimes you also get other options based on your settings, too. Make a note of the initial setting (typically "Not configured"), in case you ever need to reset your policies.

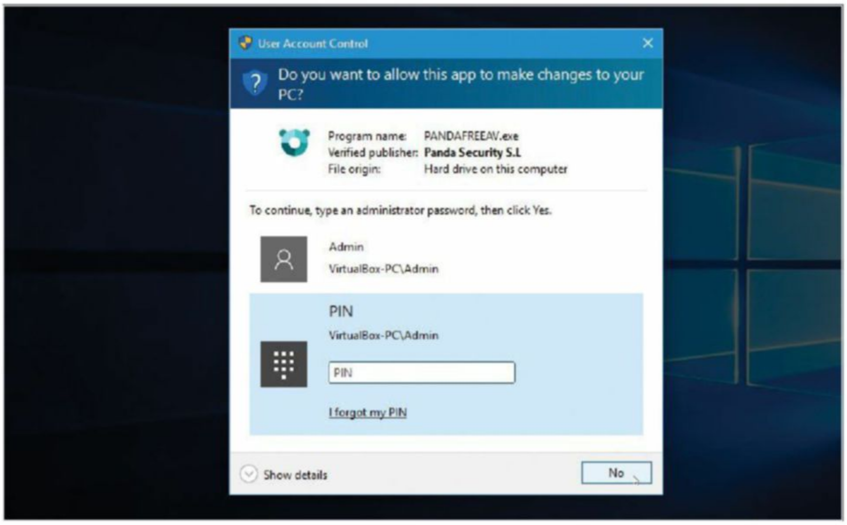
If you want to block access to a specific program that's been installed, expand "Windows Settings → Security Settings → Software Restriction Policies," and choose "Action → New Software Restrictions Policy." Select "Additional Rules," then "Action → New Path Rule." Click "Browse" to select the parent folder of a program you wish to block, leave "Security level" set to "Disallowed," and provide a description to help identify the rule going forward. Click "OK." Select "File → Save," then close the window, and reboot your PC. Test the rule by logging into the user account in question, then try launching the program—you should see a message telling you it's blocked.

Sadly, this granular level of control is restricted to Windows 10 Professional users only. However, you don't need to try to enforce Family Safety on your 30-something room-mate in order to restrict their access to programs—you can achieve much the same thing through the use of permissions.

File and folder permissions

Windows' NTFS filesystem applies permissions to files, folders, and other objects (even individual Registry entries). This gives you control over your PC by specifying which users and groups have access to which files and folders, and what level of access they have.

By way of explanation, open the C:\Users folder to view each individual user's personal folder. Inside here are their personal directories (Documents, Downloads, and so on), and various other account-specific files and settings. Try to open a folder other than your own user directory, and you get an "Access Denied" error. All well and good—except that if you're running as an administrator, you're



Do you want to allow this app to make changes to your PC?

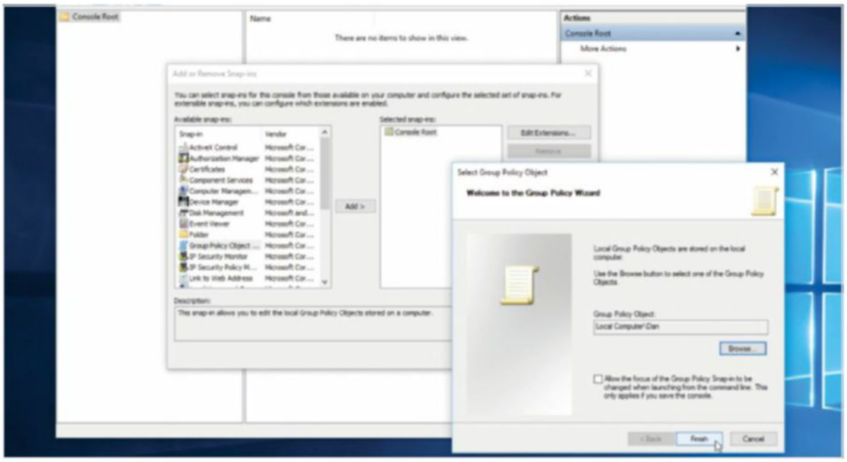
Program name: PANDAFREEAV.exe
Verified publisher: Panda Security S.L
File origin: Hard drive on this computer

To continue, type an administrator password, then click Yes.

Admin
VirtualBox-PC\Admin

PIN
VirtualBox-PC\Admin
PIN
I forgot my PIN

Going forward, you'll need to supply a password for administrative tasks.



Windows 10 Pro users can go to town on user restrictions.

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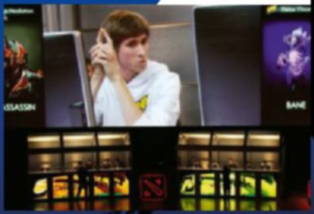

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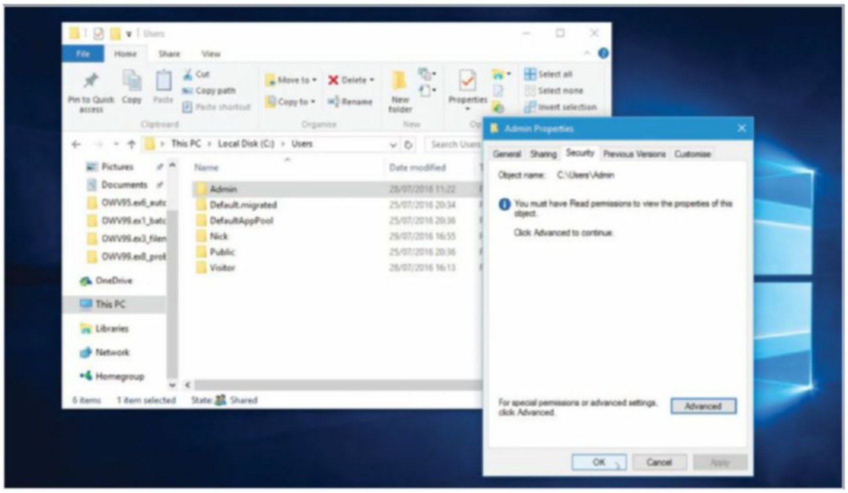

Admin Properties

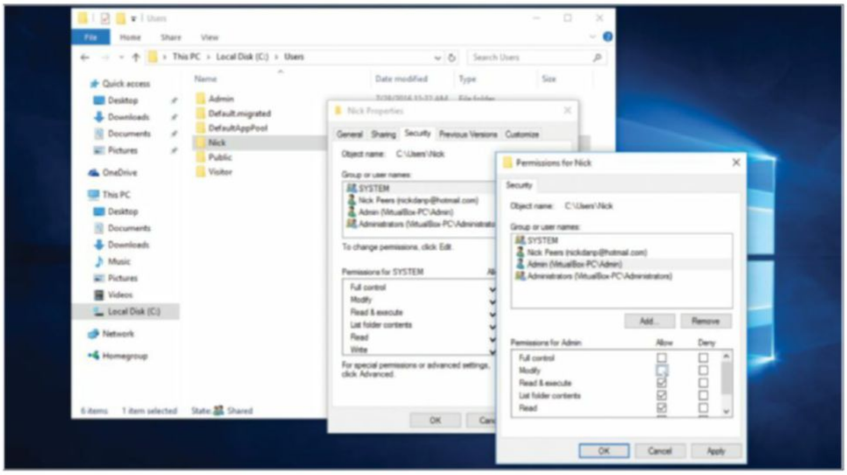
Object name: C:\Users\Admin

You must have Read permissions to view the properties of this object.

Click Advanced to continue.

For special permissions or advanced settings, click Advanced.

You need read-only access to view a file or folder's permissions.



Folder and file permissions are set on an allow or deny basis.

prompted to click "Continue" to be granted access to the folder. Not exactly secure.

Paranoid users wishing to keep specific files and folders private should investigate a third-party encryption app, such as the open-source Veracrypt (https://veracrypt.codeplex.com), where you create a password-protected "file container," which acts like a virtual drive, inside which you store your most sensitive files.

However, if you're the only one with access to the Admin account on your PC, and you trust yourself not to abuse that power, then Windows' NTFS permissions are adequate for basic privacy. To view a folder or file's permissions, right-click it, choose "Properties," and switch to the "Security" tab. You need read-only access to the item in order to view its permissions; if this is the case, you'll see a list of "Group or user names," plus permissions for the selected group or user.

Groups are basically collections of users, and include the following: Administrators, Users, SYSTEM, and Everyone. Anyone who is a standard user is part of the Users group, for example, while Everyone is a group designed to allow you to set universal permissions for every single person who uses your PC.

Permissions consist of various types: Read, Write, Read & Execute, List Folder Contents (folders only), Modify, and Full Control. Some permissions are a combination of others—for example, Modify allows you to read, write, and delete, so both Read and Write permissions are set to "Allow" if Modify is. Read & Execute provides you with both read access to a

Transfer to a New PC

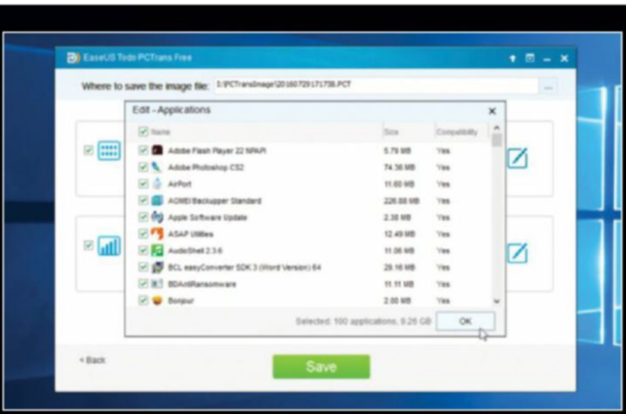
You've purchased a new PC and want to transfer your stuff across—copying data is simple, you can either set up a shared folder on your new PC and shunt everything across, before moving it to its new home, or use an intermediary device, such as external hard disk.

That's all well and good, but what if you want to move across key user settings, and maybe even programs, too? If you use the same Microsoft Account on both old and new PC to log into Windows, then some tweaks will come across, but if you're looking to simply replicate your old setup on your new PC—including desktop programs and carefully crafted settings—you'll need to get out your wallet and employ the services of a third-party program.

The best tool is PCmover (http://pcmover10.laplink.com). The Express edition ($19.95) can move files, settings, and user profiles, but if you want to move apps, you need PCmover Professional ($39.95). Transfer via the supplied Ethernet cable, or use an external drive as an intermediary—but this greatly lengthens the process.

An alternative is EASEUS PCTrans, which comes in Free and Pro ($29.97) versions (www.easeus.com/free-pc-transfer-software). The former enables you to transfer data, plus two apps (the Pro has no limitation).

If you want to transfer software that's been activated, you need to find out how to deactivate it on your old PC, before reactivating it on your new one. Also, don't rush to dispose of your old PC once you've transferred everything across. Make sure it all appears to be in order, and consider taking one last fail-safe drive image of your old PC using Macrium Reflect Free (www.macrium.com/reflectfree.aspx), ensuring that you can browse the image's contents to grab anything that might have been left behind.


EaseUS Todo PCTrans Free

Where to save the image file: I:\PCTransImage\20160729171738.PCT

Edit - Applications

Name	Size	Compatibility
Adobe Flash Player 22 NPAPI	5.79 MB	Yes
Adobe Photoshop CS2	74.36 MB	Yes
AirPort	11.60 MB	Yes
AOMEI Backupper Standard	226.88 MB	Yes
Apple Software Update	2.38 MB	Yes
ASAP Utilities	12.49 MB	Yes
AudioShell 2.3.6	11.06 MB	Yes
BCL easyConverter SDK 3 (Word Version) 64	29.16 MB	Yes
BDAntiRansomware	11.11 MB	Yes
Bonjour	2.00 MB	Yes

Selected: 100 applications, 9.26 GB

Transfer apps as well as data and settings with PCTrans.

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file, plus the ability to execute it—vital for program and script files, for example—and it's this attribute you can tweak to block individual users' access to specific programs, as we'll see shortly. Finally, Full Control basically gives you carte blanche—read, write, execute, delete, and so on.

Change permissions

File permissions are a dangerous subject—it's all too easy to lock yourself out of a file, or even mess up your entire Windows installation, if you screw around with no real thought for the consequences. So, before you begin, consult our backup feature from the June issue for advice on taking a full Windows drive image, which you can roll back to should the worst happen.

Second, limit yourself to tweaking permissions for non-system files and folders. That means making any of the root folders on drive C off limits—even with programs, you'll want to limit yourself to a specific sub-folder inside Program Files and Program Files (x86). Instead, focus on individual user folders, or folders and files you've got stored on a data partition or drive.

Third, you don't necessarily need to be logged on as an administrator to make changes to a file or folder's permissions. Two types of user can modify permissions—any member of the Administrators group (so your Admin user, for example), and the "owner" of the item in question. Who's the owner? Typically, this is the user account that created the file—for example, when you set up and save a new document, the file is assigned to you as owner. Note you can edit permissions using your Admin credentials, without logging on to the account itself.

You've reviewed the permissions for your target file and folder, and now you'd like to change them. Click the "Edit" button. You can now select a user or group to view their permissions, plus make changes using the checkboxes underneath "Allow" and "Deny." If you select certain permissions (say, Read & Execute), then other permissions (Read in our example) may be checked, too. If you choose to explicitly set a permission type to "Deny," Windows throws up a warning about group permissions, and how this overrides them. What this means is that even if the group a user belongs to has access to that folder or file, choosing "Deny" (rather than leaving both "Allow" and "Deny" boxes unchecked) explicitly tells Windows to ignore the group permission settings for that user.

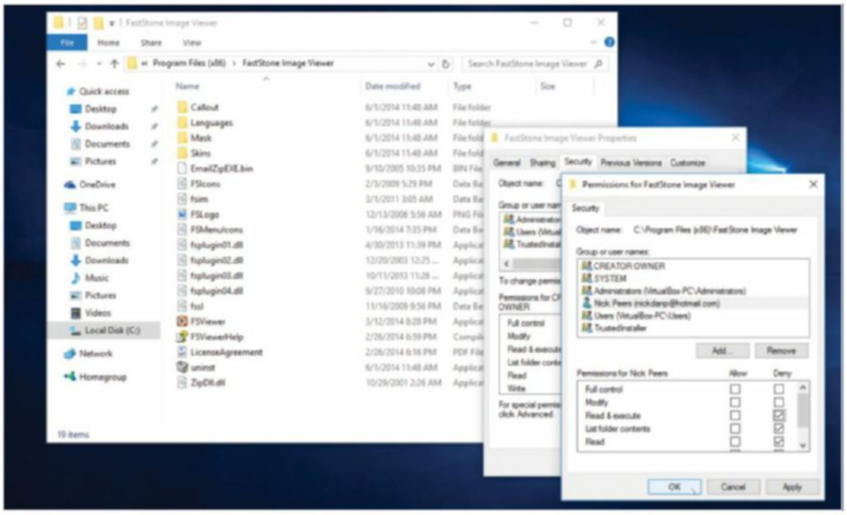
You'll also see "Add" and "Remove" buttons—these enable you to select additional users or groups, plus remove existing ones, so they either have no access, or rely on their group permissions to have access. Click "Add," and you need to type the name of your user, then click "Check Names" to select them before clicking "OK" to set their permissions.

Once done, click "Apply," and Windows starts to set permissions for that item; if you've selected a folder, then all the items inside it are set the same permissions, too. Don't panic if you get an "Access denied" error applying security—it means access is restricted to that folder, so the settings remain unchanged. Click "Continue" to carry on.

Block access to programs

So, how can you use permissions to restrict access to a certain program? Note that the following doesn't work with certain system-installed programs, such as Internet Explorer, but should work with any applications that you have installed yourself. First, browse to the program's executable file (typically inside the Program Files or Program Files (x86) folders). Right-click the file, and choose "Properties → Security tab." Click "Edit," then click "Add" to select the user you wish to block. Once added, check the "Deny" box next to "Read & Execute," and click "OK." Note the warning, and click "OK" again.

Now when that user attempts to open the program in question, they're shown a dialog telling them they can't access it due to permissions issues. They won't be able to change the file's permissions (or view them)



Object name: C:\Program Files (x86)\FastStone Image Viewer

Group or user names:
- CREATOR OWNER
- SYSTEM
- Administrators (VirtualBox-PC\Administrators)
- Nick Peers (nickdanp@hotmail.com)
- Users (VirtualBox-PC\Users)
- TrustedInstaller

Permissions for Nick Peers	Allow	Deny
Full control	☐	☐
Modify	☐	☐
Read & execute	☐	☑
List folder contents	☐	☑
Read	☐	☑

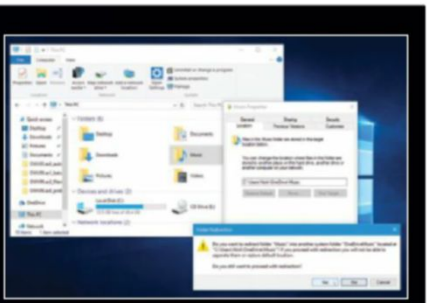
Use permissions to block individual users from launching programs.

Fully Integrate OneDrive

One annoyance with Windows is how it bakes support for OneDrive into the operating system, while separating its folders from your user account. That means you end up with two of all your key user folders.

Interestingly, you can merge OneDrive's folders with those in your user account, making things simpler to manage, but it's a one-way process—unmerging the two later isn't an option. If that doesn't put you off, browse to your user folder, right-click your Documents folder, and choose "Properties → Location tab." Click "Move," then browse to the corresponding directory inside your OneDrive folder, and click "Apply." Click "Yes" to move existing files into the new location, then read the warning before clicking "Yes." Repeat for any other system folders you wish to integrate.

One thing to consider—the size of your OneDrive storage. You only get 5GB for free, so unless you've paid for additional storage, or have subscribed to Office 365, this may prove to be a non-starter. In that event, make use of Libraries instead. Windows 10 may have hidden them, but Libraries are still very much a part of it. Open a File Explorer window, switch to the View tab, and click the "Navigation pane" button—check "Show libraries" to put them back in the navigation pane. From here, select the Libraries view, right-click each Library in turn, and choose "Properties." Click "Add..." to add the corresponding OneDrive folder to that Library, and click "Include folder" followed by "OK." The folders remain separate, but they're easier to switch between.



unless they have administrator access. It's a crude method, but it works.

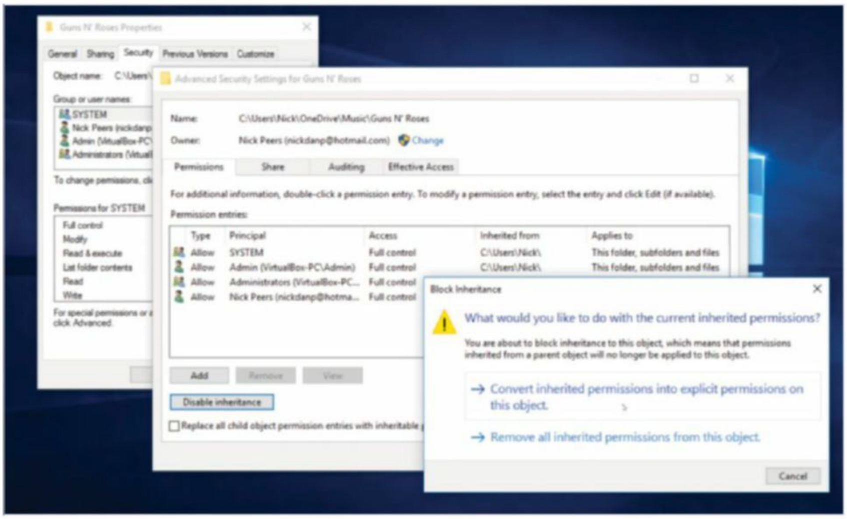
Take ownership

You'll notice an "Advanced" button on the Security tab of a file's properties. Click this, and you gain the ability to view more information about the permissions assigned to individual users, complete with an "Inherited from" field that shows which folder the permissions were assigned from.

Look out for a button marked "Disable inheritance"—click this to unlink the item from its parent folder. What this means is that any permission changes you apply to the parent won't automatically apply to this file or sub-folder going forward. When prompted, choose the "Convert" option to apply the parent's settings to the item before removing the link, or "Remove" to clear them all. The latter option scrubs all existing permissions, blocking all access to the file or folder until new permissions are set by the item's owner. Note, however, that nothing actually happens until you click the "Apply" button—click "Cancel" to make no changes.

You'll also see a line listing the "owner" of the item in question. From here, you can change ownership to another user or group. You might do this to prevent the original owner—assuming they're a standard user—from undoing any permission changes you implement. You might also do this to take back ownership of a file or folder after you've either switched to a new user account (perhaps your old account corrupted), or reinstalled Windows in certain circumstances.

Taking the latter as an example, you might reinstall Windows from scratch using a different username and/or password, leaving your data folders on a separate drive or partition. You then find you're locked out of these folders because they're assigned to the old user account (even though it no longer exists). You can regain access to the folder via the "Continue" button while logged on as an administrator, then transfer ownership to your new account.



Object name: C:\Users\

Group or user names:
SYSTEM
Nick Peers (nickdanp
Admin (VirtualBox-PC\
Administrators (Virtual

To change permissions, cl

Permissions for SYSTEM
Full control
Modify
Read & execute
List folder contents
Read
Write

For special permissions or a
click Advanced.

Name: C:\Users\Nick\OneDrive\Music\Guns N' Roses
Owner: Nick Peers (nickdanp@hotmail.com) Change

For additional information, double-click a permission entry. To modify a permission entry, select the entry and click Edit (if available).

Permission entries:

Type	Principal	Access	Inherited from	Applies to
Allow	SYSTEM	Full control	C:\Users\Nick\	This folder, subfolders and files
Allow	Admin (VirtualBox-PC\Admin)	Full control	C:\Users\Nick\	This folder, subfolders and files
Allow	Administrators (VirtualBox-PC...	Full control		
Allow	Nick Peers (nickdanp@hotma...	Full control		

☐ Replace all child object permission entries with inheritable

Block Inheritance

What would you like to do with the current inherited permissions?

You are about to block inheritance to this object, which means that permissions inherited from a parent object will no longer be applied to this object.

→ Convert inherited permissions into explicit permissions on this object.

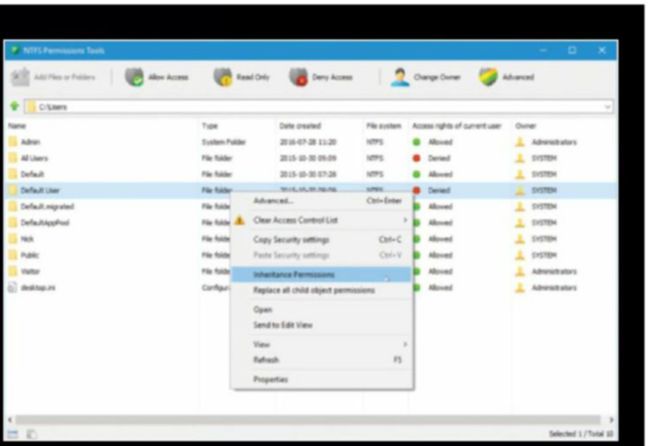
→ Remove all inherited permissions from this object.

Inheritance is used to apply a folder's permissions to its contents.

What you'll see when you view the item's permissions is an "Account Unknown" entry with a name like "S-1-5-25-12345." This refers to your previous, redundant account. Click "Advanced," and you see it's the owner of the folder, so click "Change" to transfer ownership to your new account, allowing you to set the permissions you need.

And there you have it—everything you need to know about locking down your PC that little bit tighter. Of course, things can—and do—go horribly wrong when messing about with permissions. Before reaching for your backed-up image of Windows, though, check out the box below, which contains information about some handy tools that can help resolve problems with permissions-related issues, both self-inflicted and otherwise.

Fix Problems Related to Permissions



C:\Users

Name	Type	Date created	File system	Access rights of current user	Owner
Admin	System Folder	2016-07-28 11:20	NTFS	Allowed	Administrators
All Users	File folder	2015-10-30 09:09	NTFS	Denied	SYSTEM
Default	File folder	2015-10-30 07:28	NTFS	Allowed	SYSTEM
Default User	File folder	[illegible]	[illegible]	Denied	SYSTEM
Default.migrated	File folde			Allowed	SYSTEM
DefaultAppPool	File folde			Allowed	SYSTEM
Nick	File folde			Allowed	SYSTEM
Public	File folde			Allowed	SYSTEM
Visitor	File folde			Allowed	Administrators
desktop.ini	Configur			Allowed	Administrators

The unthinkable has happened to your PC—either you have botched your attempts to tweak the permissions for a particular file or folder, or Windows has run into permissions issues all on its own. So, what can you do to resolve the problem? You should start by seeing whether an official Microsoft troubleshooter can help—download and run it from https://support.microsoft.com/en-us/help/17590/. This tool attempts to automatically diagnose (and crucially fix) problems that are due to issues with permissions, which means that everything from problems emptying the Recycle Bin and moving or renaming files, to keyboard shortcut issues in File Explorer is covered.

Another handy tool that can help resolve—albeit in a rather crude way—permissions-based issues is the Windows Repair Tool. Download the tool (a portable version is available should you not wish to install it) from www.tweaking.com, then switch to the "Repairs" tab. Click "Open Repairs," uncheck "All Repairs," then examine the first two repairs: one fixes issues with the Registry, while "Reset File Permissions" allows you to attempt fixes on selected drives. The tool sets things back to their defaults, so your PC remains secure and hopefully fully functional after the repair completes. It can take some time to complete, so be prepared to wait a while.

One final tool to look at is NTFS Permissions Tools (www.dbcstudio.net). This provides an alternative means of browsing and editing permissions. You're provided with a File Explorer-like view of your drives, with your access rights and the folder or file's owner marked. There are buttons for changing access levels and the owner, plus an Advanced section similar to that found in Windows. Also check out the options available when you right-click a folder, including one that lets you copy and paste permissions settings between items.

Future

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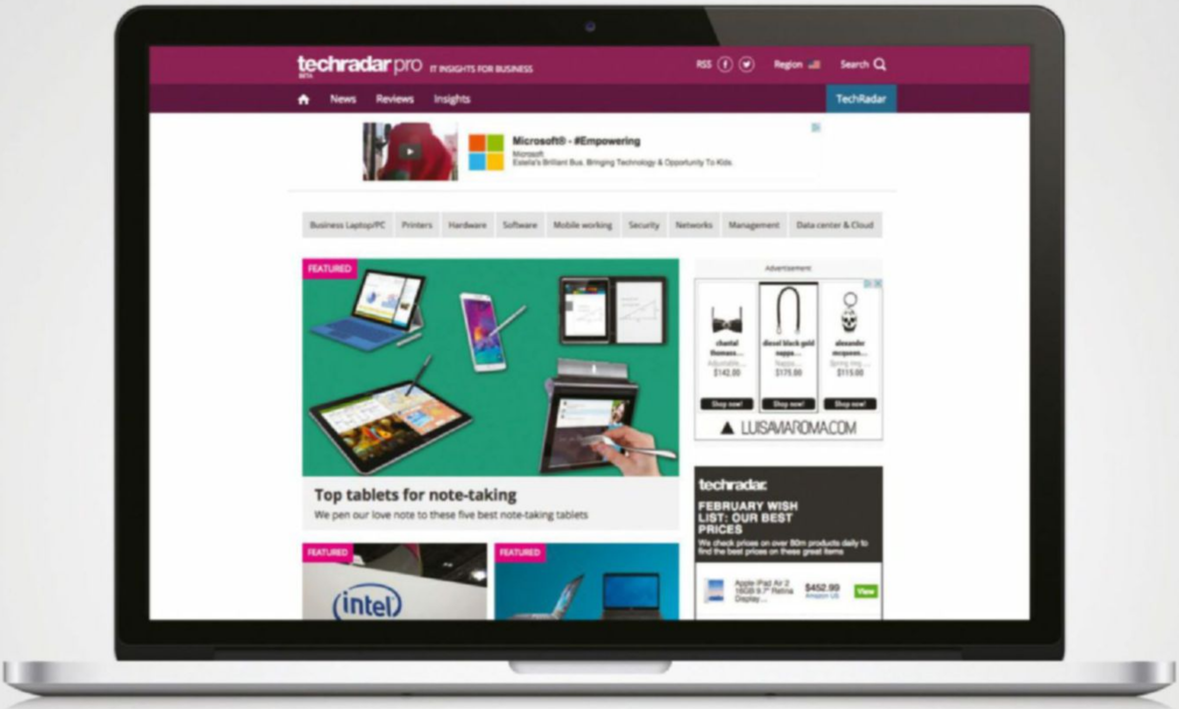
IT INSIGHTS FOR BUSINESS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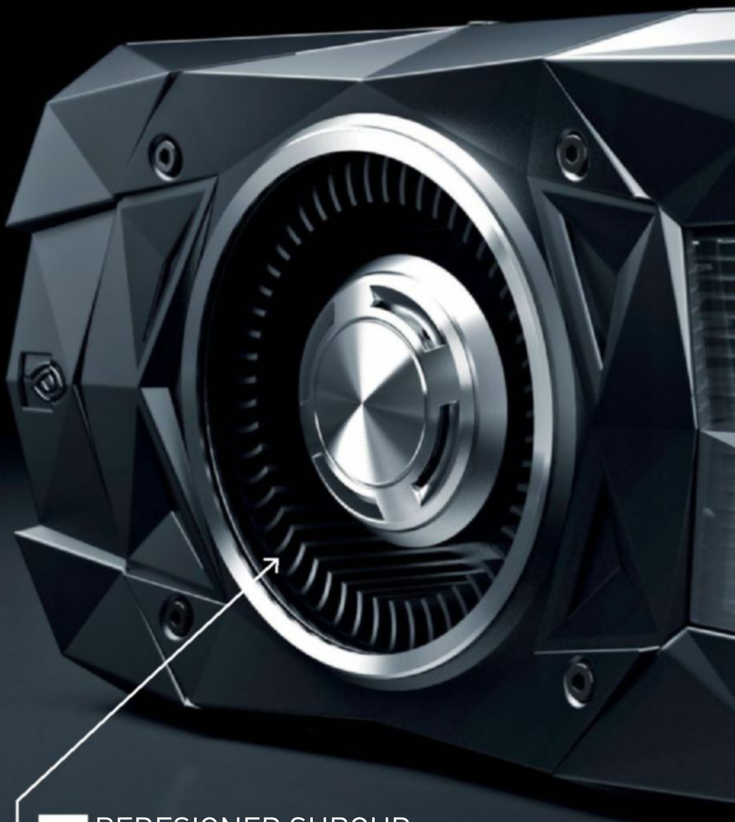
TECH PORN

Nvidia Titan X

TECHNOLOGY HAS ADVANCED more over the last 30 years than during the rest of human history. Think back to *Pong,* the Commodore 64, the Atari 2600, the Sega Saturn. Think back to the games we used to play. Look back at the earliest PlayStations and personal computers, at *Half-Life, Medal of Honor, Tomb Raider,* and *Freelancer.* Look back to *Crysis,* to *Far Cry,* to *Call of Duty,* and take a moment to appreciate just how far we've come in such a short space of time.

As long as there's been silicon in processors, graphical fidelity has led the way in driving the consumer market forward, pushing manufacturers to test the limits of what they can achieve with each of those minuscule chips.

The Titan X is the epitome of this ethic, the yardstick against which all graphical performance is measured, and the pinnacle of Nvidia's polygon-rendering arsenal. Each generation brings with it the absolute best of the best that Nvidia can muster, and if money is no object, it's the solution to all your graphical troubles. Pascal's 16nm FinFET variant is no different. Although by no means cost-effective, it is, as the name suggests, titanic in its proportions. A card to beat all others—and in a high-end market with little competition right now, it does exactly that. **–ZAK STOREY**



1 REDESIGNED SHROUD

Look familiar? It should—this is Nvidia's latest Pascal polygon pixel-pushing cooling solution. With a single fan blower design, the Titan X mimics the GTX 1080 and 1070 Founder's Edition cards, with a sleek new redesigned cooler, but with one big difference: a sexy black tint to the whole affair. Sleek and quiet, the Titan X should remain insanely cool under load and in your rig.

3 3,072

That's the number of CUDA cores this little beauty has—almost 1,000 more than the top-end GTX 1080. Performance figures aren't that amazing yet, but this card was made for developers, not gamers. It does suggest what we might get with regard to a GTX 1080 Ti. With driver optimization, it could be a 20–30 percent increase in performance over the GTX 1080.

2 NO HBM? NO PROBLEM.

Although there's still no hint of HBM 2.0 on any of the flagship cards, the Pascal Titan X comes with a whopping 12GB of GDDR5X on a 384-bit memory bus. By far the biggest we've seen, it should allow for an effective memory bandwidth of up to 336.5GB/s, making it ideal for 4K and beyond.

THE UNFINISHED

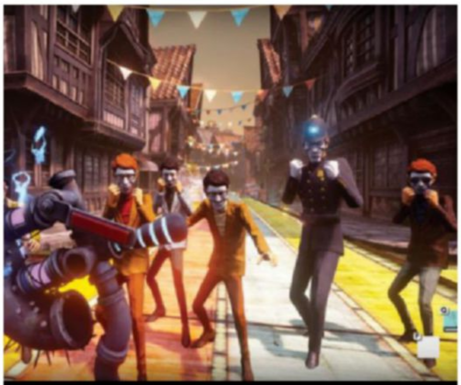
Take a trip into Early Access, where baby games go to grow up

BY IAN EVENDEN

BUYING AN EARLY ACCESS GAME on Steam seems like a gamble. You want us to pay money for something that's not finished, and will be full of bugs and empty of content? Yet, when you consider the popularity of Kickstarter, where people put down money on the basis of an idea alone, Valve's system starts to look less problematic. You get the game, in whatever state it's in, you get the chance to play it early, and feed back information about bugs and problems to the developer, and you get to keep it when it's finished.

A lot of these aren't expensive games, and many have simple graphics and low system requirements, but Early Access is the home of the sort of title that might not get made any other way. Thoughtful games, slow games, miles away from the shock and awe of big-budget development. They're being shaped by their players as much as their makers, who are more likely to be indie studios or even bedroom coders than massive game factories.

That's the joy of Early Access games—the feeling that you're in on something from the start, and that you could help shape the final product. It may be buggy or even unplayable at the beginning, but it gives you a sense of investment that you just don't get from a corporate creation. Here, then, is a selection of what's out there.

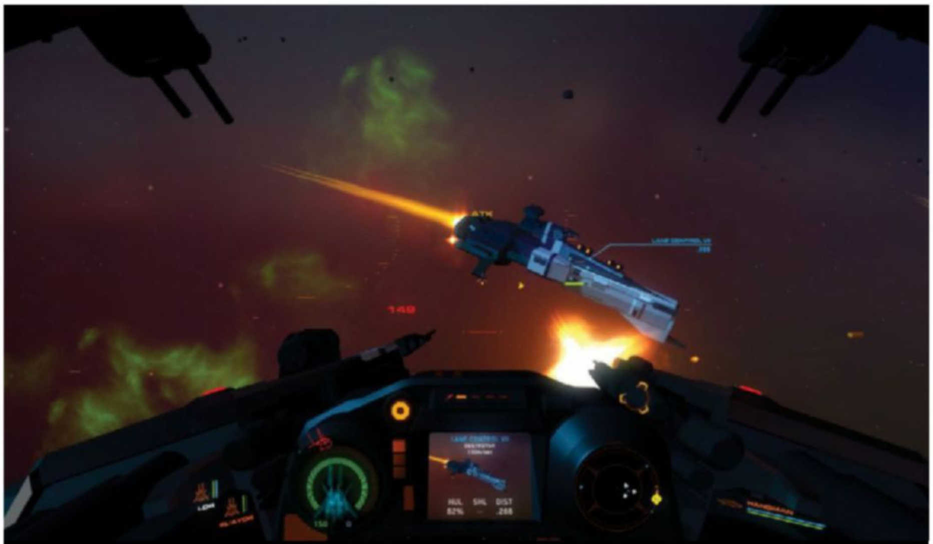


We Happy Few

A SURVIVAL GAME like no other, you have to blend in with the inhabitants of a retro-futuristic British city, where everyone has to be happy, all the time. Or else. The city is procedurally generated, so no two plays will be the same, and the art style is striking. The developers promise a "fully voiced, cinematic, first-person story," in addition to running around, bashing things.

» **Developer:** Compulsion Games

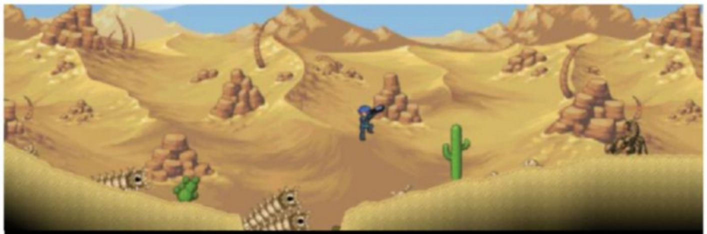
» **Price:** $30



House of the Dying Sun

VR AND SPACE go together like Trump and Pence: made for each other but a bit awkward in practice. With its blend of real-time and tactical combat, *HOTDS* lets you jump from cockpit to cockpit while controlling your fleet of fighters, before zooming right out for a commander's overview of the battle. There's support for Oculus Rift, Vive, and 21:9 monitors.

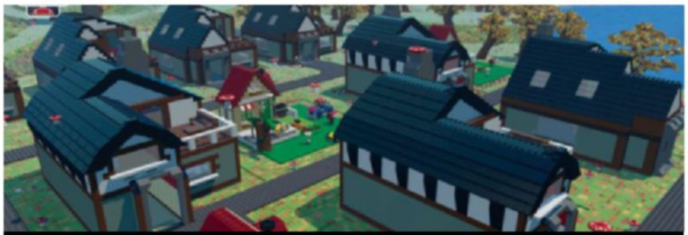
» **Developer:** Marauder Interactive, LLC » **Price:** $20



Planet Centauri

A 2D SIDE-SCROLLING adventure featuring dinosaurs, spaceships, fairies, mechs, sandworms, dragons, gorillas, and more, *Planet Centauri* takes the systems and complexity of a huge 3D RPG and hides it behind a simple art style as you explore a planet and sow the seeds of a new civilization there.

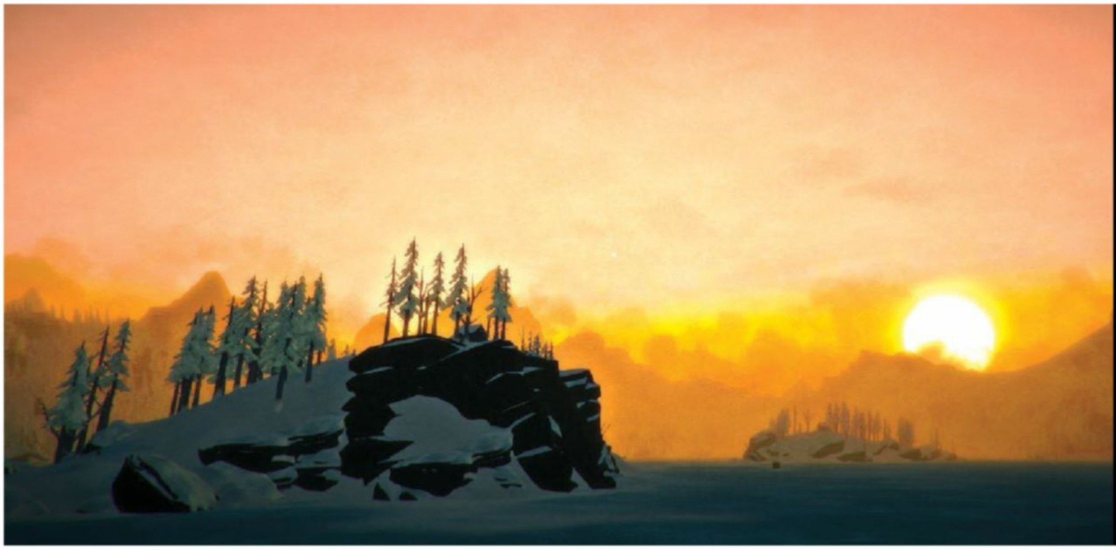
» **Developer:** Permadeath » **Price:** $15



Lego Worlds

A "FULLY OPEN-WORLD, creativity-driven game" that involves blocks. Yep, it's Lego's attempt at a *Minecraft,* and features a procedurally generated world in which to play with your creations. Potentially huge if TT Games can pull it off, the big milestone will be the success of the yet-to-be-added online multiplayer.

» **Developer:** TT Games » **Price:** $15

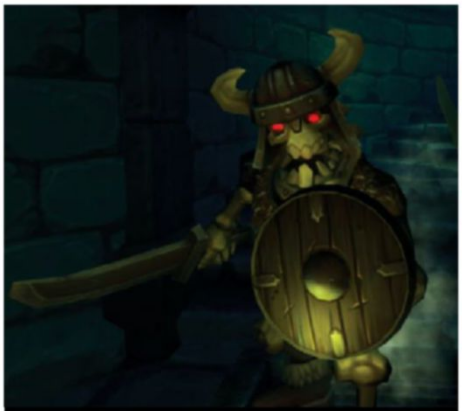


The Long Dark

AS A GAME that's been in Early Access for two years, you'd be forgiven for expecting *The Long Dark* to be finished by now, but this permadeath survival game that crash-lands you in the Canadian wilderness continues to see development, with over 75 updates applied since launch, at an average of more than three a month.

» **Developer:** Hinterland Studio Inc.

» **Price:** $20

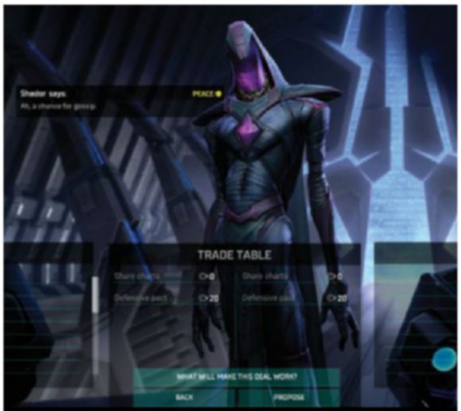


Vanishing Realms

WITH A NAME that sounds like it belongs on a console game comes an interesting premise—a first-person RPG designed exclusively for VR, which uses the Vive's controllers to power motion-controlled combat. It's currently being released as chapters, with two fully available, and lasting up to two hours each.

» **Developer:** Indimo Labs LLC

» **Price:** $20

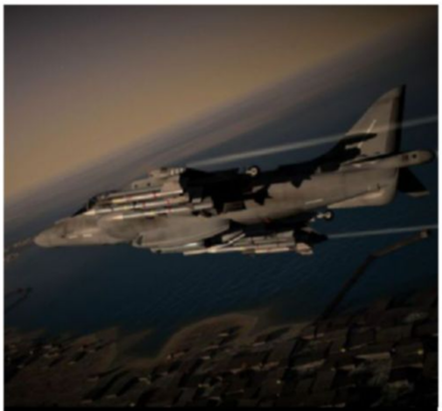


Master of Orion

A REBOOT of the 1993 sci-fi 4X strategy game, *Master of Orion* is being published by Wargaming.net, home of *World of Tanks* and its spin-offs. The Early Access version is limited to six races, which will jump to 10 on full release, but otherwise this is already a polished strategy title that appears largely complete.

» **Developer:** NGD Studios

» **Price:** $50



Combat Air Patrol 2

WHEN WAS the last time we had a good flight sim? With geographically accurate terrain around the Strait of Hormuz to fly your Harrier II around, *Combat Air Patrol 2* also has you undertaking strategic planning and moving naval units, before you take to the skies and start launching missiles.

» **Developer:** Sim155 Limited

» **Price:** $30

Kings and Heroes

A FIRST-PERSON fantasy RPG, with six races and five classes to choose from, *Kings and Heroes* will feature an open world, with PvP combat, and a level editor. There are already more than 20 boss-level creatures in place, and a number of recent performance patches point to a game being optimized for launch.

- **Developer:** Industry Games
- **Price:** $30

Trapper's Delight

A MULTIPLAYER GAME in which you set a gauntlet of devious traps for other players to navigate, the twist with *Trapper's Delight* is that you're also in there with them, so they can learn by watching out for your avoidance of the triggers you placed. Spectacular moments can be exported as an animated GIF, for social media silliness.

- **Developer:** Shrimpcave Industries
- **Price:** $9.99

Final Strike

VIRTUAL REALITY, military jets, and aliens. It's not just the list left for Santa by many of the *Maximum PC* contributors, but a concise description of *Final Strike*. Supporting Vive and Rift for an immersive cockpit experience, or just a plain old-fashioned monitor, the developers have clearly been watching too much *Independence Day*.

- **Developer:** Ghost Machine
- **Price:** TBC

GRIP

ANOTHER DEAD GENRE has the voltage applied, and combat racing rises from the grave. *Rollcage*-inspired *GRIP* currently features only two cars, five tracks, and four ways to blow one another up in single-player or split-screen multiplayer, but the developers are working on adding online modes and more explosions.

- **Developer:** Caged Element Inc.
- **Price:** $16

In Case of Emergency Release Raptor

THE *JURASSIC PARK* version of the velociraptor—too big, no feathers—rampages through a robot-dominated future in this exercise in wish-fulfilment. Your dromaeosaurid isn't armed with lasers like the bots it hunts, so getting close enough to rip them apart with your talons is the order of the day.

- **Developer:** Arcen Games, LLC
- **Price:** TBC

BallisticNG

A FREE *WIPEOUT* clone whose website appears to be a GitHub repository, *BallisticNG* has a retro look and low system requirements. Five classes build up to ridiculous speeds as racers fight their way around 14 tracks, and modding tools let you put your own stamp on things.

» **Developer:** Vonsnake

» **Price:** Free

YouTuber's Life

WORK YOUR WAY up to be the world's greatest YouTube superstar, by video editing, and earning money to buy more games so you can earn more money—the sort of slow-build snowballing common to tycoon games. With some thoroughly modern subject matter, *YouTuber's Life* has pushed the management sim back to the Steam bestsellers list.

» **Developer:** U-Play online » **Price:** $15

Space Pirates and Zombies 2

A PERSISTENT UNIVERSE with 200 AI captains lies behind *SPAZ2*. As a commander, you can go to war or make alliances, as you build up your ships from randomly generated parts and collect resources. Once you've set up a faction, you can defend it with star bases and power it with resource hubs, but meeting other captains generally leads to combat. Battles attract other captains looking for salvage, and the developer is hinting at "darker threats" emerging.

» **Developer:** MinMax Games Ltd

» **Price:** $20

BIGHORNED RAMMER
12.8
USE THIS CREATURE
BREED AGAIN
0:25

Hybrid Animals

PICK TWO ANIMALS, and the game mashes them together. Like what you see, and you can take the unholy creation into battle against your friends, or choose again. A story mode with a randomly generated world is incoming, along with support for sharing your creations.

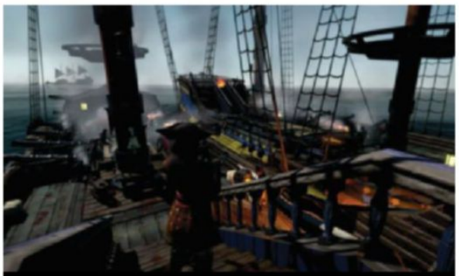
» **Developer:** Harrison Walters

» **Price:** $12

Jalopy

DRIVE THROUGH RECREATIONS of post-Cold War eastern Europe and into Turkey, upgrading, repairing, and generally caring for your car. Put like that, it sounds like it could be a disaster, but with an allegorical storyline exploring the fall of communism, the presence of your uncle in the car, and the tension of smuggling contraband past border guards, *Jalopy* could almost be a survival game, but for the lack of zombies.

» **Developer:** Minskworks » **Price:** $13



Man O' War: Corsair

PIRACY IS ALWAYS popular in PC gaming, but with *Sea of Thieves* heaving to, there's never been a better time to hoist the Jolly Roger. Based on the *Man O' War* tabletop game, *Corsair* features exploration and naval combat with 50 ports to visit.

- » **Developer:** Evil Twin Artworks
- » **Price:** $30

Factorio

A COMPULSIVE factory-building game, the Steam reviews tell of gigantic installations and mammoth playtimes. The game world is infinite, even if the resources aren't, so you must keep exploring, and defend yourself against the planet's residents.

- » **Developer:** Wube Software Ltd
- » **Price:** $20

Kingdoms

DOES THE PHRASE "randomly generated medieval RPG" set your heart racing? What if it's filled with NPCs who do their thing without your input? You can lead them, help out, or explore and kill the wildlife. VR support is being worked on.

- » **Developer:** Max Peskov
- » **Price:** $10

Space Engineers

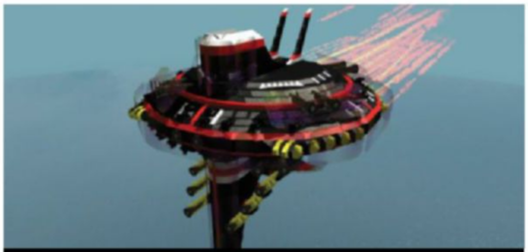
INTO ITS THIRD YEAR in Steam's Early Access system, this sandbox game about construction, engineering, exploration, and survival takes today's NASA technology and extrapolates it 60 years into the future. Multiplayer gaming can be either co-operative or competitive, while space pirates or even alien spiders can be added to the simulation if you're looking for an extra challenge.

- » **Developer:** Keen Software House
- » **Price:** $25

Black Mesa

THE FAN-MADE re-imagining of one of the best games ever still isn't finished, but the ending of *Half-Life,* all floating asteroids and strange baby-monsters, wasn't why you played the game in the first place. Battles with aliens and black-ops soldiers are all present, with upgraded textures, voices, and geometry. There are modding tools and Steam Workshop integration, along with multiplayer to keep you busy while you wait for the Xen levels to be completed.

- » **Developer:** Crowbar Collective
- » **Price:** $20



From the Depths

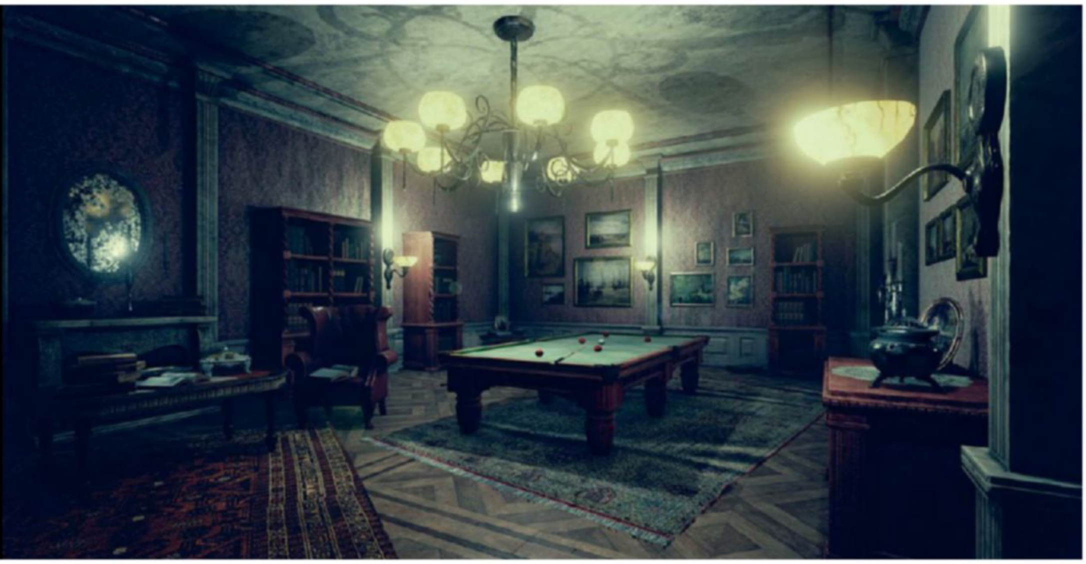
VOXELS! What was once trumped as the future of graphics tech is still a novelty, but this build-your-own-battleship game uses them to great effect, as home-made war machines face off against one another. Co-op and competitive multiplayer are coming, but single-player and the creative mode are getting positive user reviews.

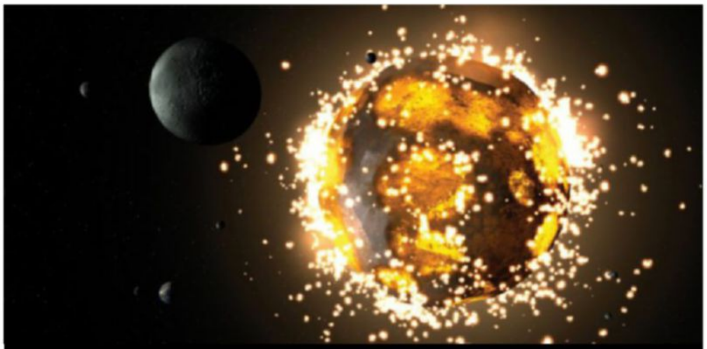
- » **Developer:** Brilliant Skies Ltd
- » **Price:** $20

Vernon's Legacy

AN ATMOSPHERIC, first-person horror-adventure-puzzle game set in an early 20th century manor, with a story supposedly inspired by real events. Running on the Unreal Engine, *Vernon's Legacy* certainly looks the part, with its dimly lit rooms and dark, heavy furniture, but as it nears completion, it's the cunningness of the puzzles that will be the true test of the game's quality.

» **Developer:** TripleBrick
» **Price:** TBC

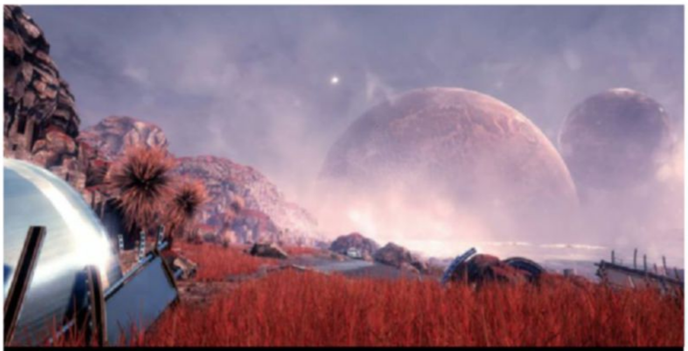




Universe Sandbox 2

A GORGEOUS PHYSICS-BASED space simulator, *Universe Sandbox 2* can scratch the itch you've always had to make planets crash into each other. More seriously, it can be used to model Earth's climate, theoretically terraform other planets, and watch as bodies form from clouds of interstellar gas. Purely a simulator without much actual "game," compatibility with the Vive enables you to view your universe as though you were really there.

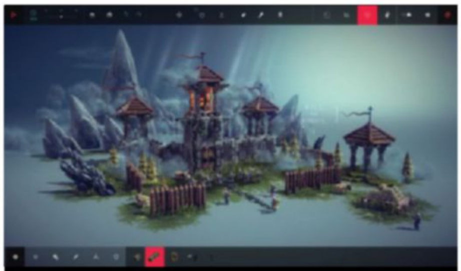
» **Developer:** Giant Army » **Price:** $25



The Solus Project

A SINGLE-PLAYER virtual reality exploration game, set on an alien planet, *The Solus Project's* developers are extremely proud of its dynamic weather systems, plants that change as a response to the climate, and the dozens of secret areas that they've built for the player to discover, as they try to scavenge enough materials to build a communications device and send a message home.

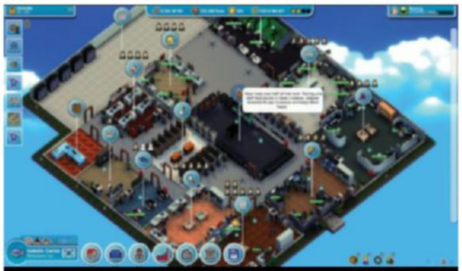
» **Developer:** Hourences/Grip Games » **Price:** $20



Besiege

CREATE TERRIFYING spiked flame-belching death machines, then crush stuff with them. *Besiege* becomes more complex as more demands are made of you, and your machine falls apart. It doesn't matter what you build, as long as it gets the job done.

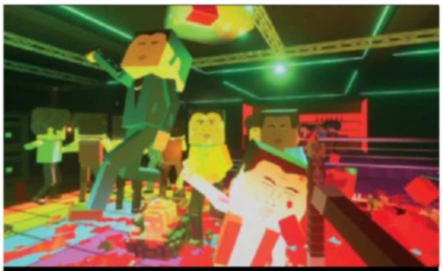
» **Developer:** Spiderling Studios
» **Price:** $8



Mad Games Tycoon

SETTING YOU UP with an indie games studio in the 1980s, *Mad Games Tycoon* tasks you with developing the games of your dreams. Complications arise in the form of deals with publishers, and the perennial problem for all businesses: employees.

» **Developer:** Eggcode
» **Price:** $15



Paint the Town Red

THIS TIME, you get to punch the voxels in the face. An over-the-top first-person melee combat game with modding tools and online co-op promised soon, *PTTR* treats anything you pick up as a weapon, and lets you slice and dice with it.

» **Developer:** South East Games
» **Price:** $10

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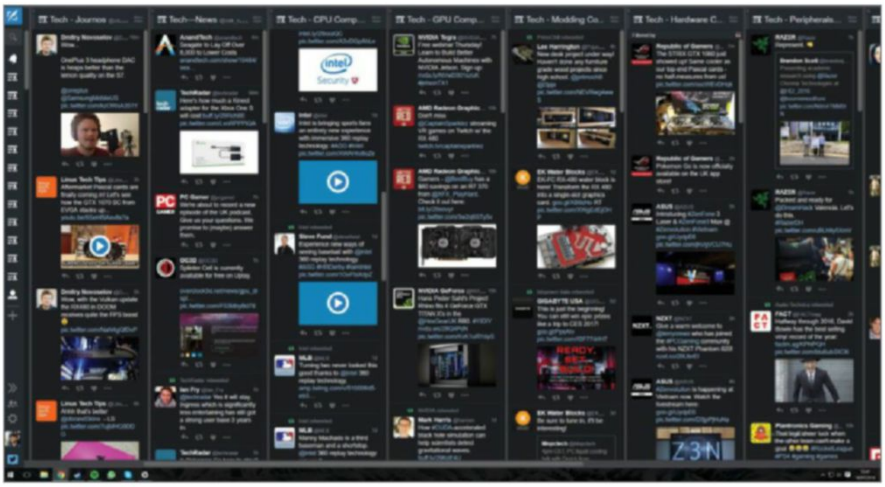
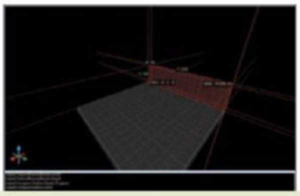


TAKE CONTROL OF TWITTER

Are you an avid Twitter user? Tweetdeck is both a standalone website and Chrome extension developed by Twitter, which enables power users to take full control of their newsfeeds and lists. Intuitive and easy to use, you can choose what lists and feeds to show, whether to see retweets, and even enable a dark mode, making it far easier to manage and catch up on the news. A great tool for journalists and hardware fans alike.

MAKE – USE – CREATE

62
Create your own Pi cloud storage using OwnCloud



66
Build a *Quake* deathmatch level with TrenchBroom

72
Put together a budget headless home theater PC

ZAK STOREY
STAFF WRITER

OVERCLOCKED GPUs

Oh god, here he goes again, talking about overclocking. Sorry, but we get asked a lot about graphics cards, and the overriding question is, "Is GPU overclocking worth it?" And the answer will vary, unsurprisingly.

As an example, take the reference Nvidia GeForce GTX 1070 and compare it with MSI's Gaming X variant. Spec for spec, these cards are identical, until you examine the clock speeds. The reference card's core clock boosts up to 1,683MHz, not accounting for GPU Boost 2.0, while the Gaming X variant boosts all the way to 1,797MHz, and throws an additional 100MHz on to the memory. Doesn't sound like much, but that minute overclock gives you a net increase of 0-5 average fps in games at 1080p, depending on the title.

You can easily go much higher than that anyway. Even the reference Founder's Edition is no pushover in that regard. In our opinion, certainly for the Maxwell and Pascal architecture, it's not worth spending any extra dough on a preclocked card, unless you know for a fact it's been pre-binned ahead of time. That said, you do get a more efficient power solution, better cooling capacity, reduced noise, and a completely new aesthetic to match your build. Couple that with the extra performance at stock without tinkering, and, well, it's up to you to decide whether it's worth it or not.

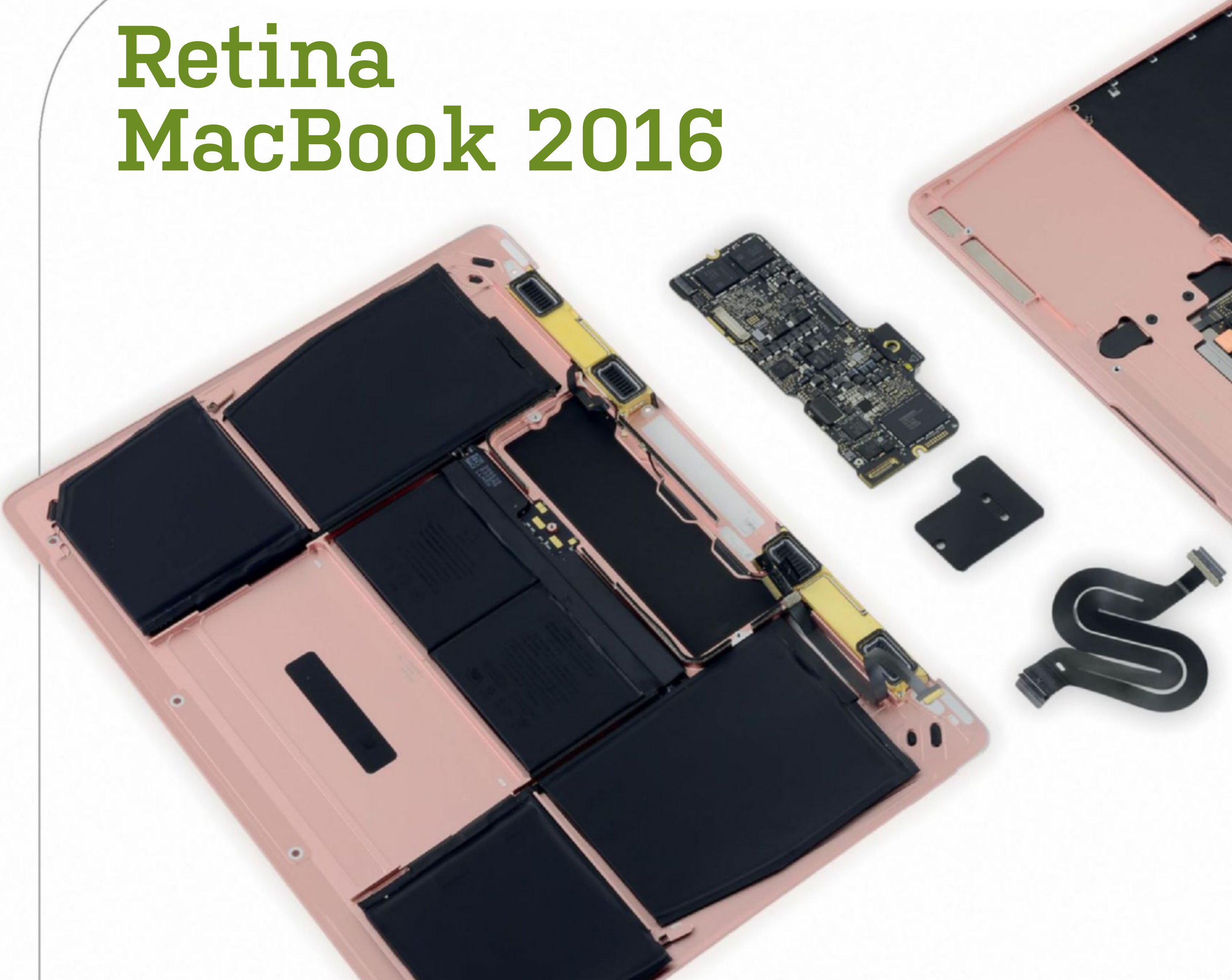
↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

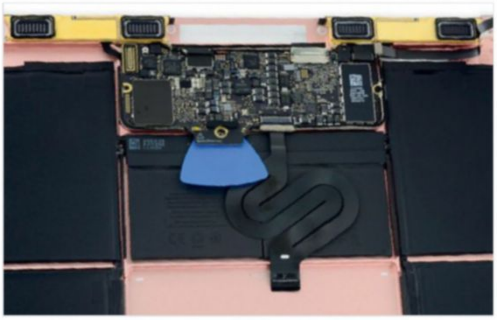
Retina MacBook 2016

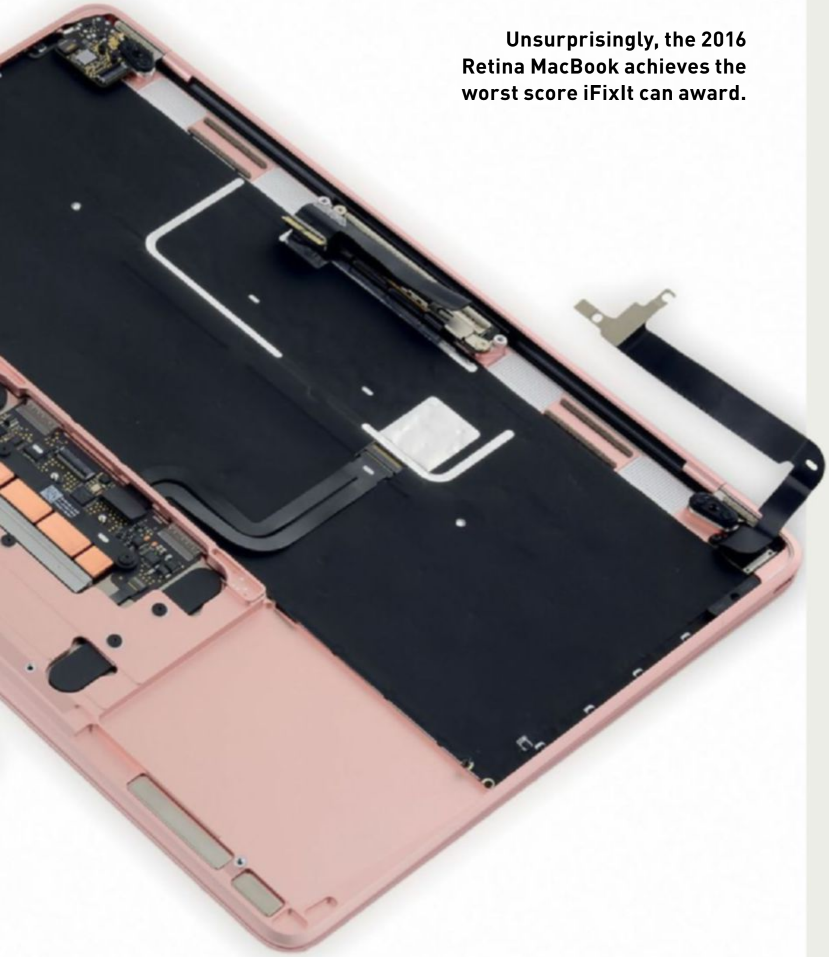


About iFixit

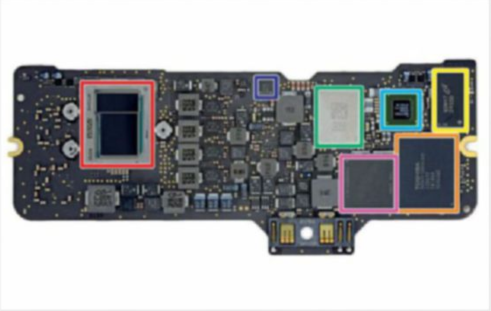
iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Apple sure does piece together some pretty systems.





Unsurprisingly, the 2016 Retina MacBook achieves the worst score iFixIt can award.



Unfortunately, all the chips are still soldered to the PCB.

BACKGROUND

Apple's first update to the 12-inch MacBook with Retina Display is a baby update, so we're matching it with a baby teardown. Beside a faster processor and zippier flash memory, what's changed? There's only one way to find out: crack it open.

MAJOR TECH SPECS

- 12-inch 2304x1440 (226ppi) IPS Retina Display
- 1.1GHz dual-core Intel Core m3 processor (configurable up to 1.3GHz dual-core Intel Core m7)
- 8GB of 1,866MHz LPDDR3 RAM
- 256GB or 512GB PCIe-based flash storage
- Intel HD Graphics 515
- 1802.11a/b/g/n/ac Wi-Fi wireless networking and Bluetooth 4.0
- Single USB-C port and 3.5mm headphone jack

KEY FINDINGS

- If it weren't for the rose gold finish, we'd be hard-pressed to distinguish this year's Retina MacBook from yesteryear's. The exteriors look identical, from the Pentalobe screws in the lower case, right down to the model number—A1534.
- The pesky tri-wing screw we saw last year grew another, um, wing—now it's a repair-friendly Phillips. Thankfully, all the other internal screws are still Phillips and Torx screws.
- At the other end of the MacBook, the USB-C hardware has also changed. The cable is now perma-fixed to the USB board, condensing the two components into a single unit. Also, the silicon is new and has moved from the cable itself to the USB board. This new USB and cable arrangement is one thing that's not compatible with previous Retina MacBooks.
- The battery's form factor seems identical to the multi-lobed cell in the 2015 MacBook, yet somehow Apple has managed to squeeze in a 4 percent capacity increase from last year's model. Apple claims the new 7.56V, 41.41Wh Li-ion power source should provide 11 hours of iTunes movie playback. We're guessing this capacity increase is owed to improved battery chemistry (though it's also possible that Apple's engineers have shaved away just enough material from the lower case to allow for a thicker battery). Unfortunately, they did not squeeze in any of those nifty adhesive pull tabs we've seen in Apple's iDevices. Regardless, our tests indicate this beefier battery is compatible with last year's MacBook. Nice!
- Repairability Score: 1 out of 10 (10 is the easiest to repair). Those pesky tri-wing screws are gone, replaced by lovely standard Phillips screws—but tamper-evident hinge screws make you feel like a hoodlum for repairing your own machine. The processor, RAM, and flash memory are still soldered to the logic board. The battery assembly remains entirely, and very solidly, glued to the lower case. The Retina display is still a fused unit with no separate, protective glass. If the display needs replacing, it'll cost a pretty penny.

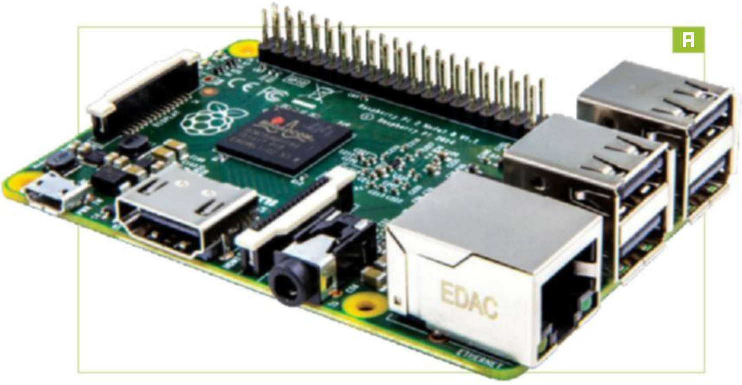
Create a Pi Cloud with OwnCloud

YOU'LL NEED THIS

RASPBERRY PI AND SD CARD/USB DISK
See www.raspberrypi.org.

OWNCLOUD
Download it from www.owncloud.org.

THERE ARE PLENTY OF CLOUD file storage and sharing services, so why would you want the hassle of setting up your own? There are many reasons, beyond the perfectly acceptable "because you can." Commercial services have limits on the amount of data you can store. They may or may not encrypt your data, but it is their encryption—you can't be sure that they can't read it. If you're sharing between computers on the same network, your data still has to go to their server, over a relatively slow upstream link, before it can be downloaded to another computer in the next room. On the other hand, commercial providers have large data farms, with plenty of redundant storage and connectivity, and, usually, comprehensive backup procedures. If you want to run your own cloud storage, you have to take responsibility for that. –**NEIL BOTHWICK**



1 ESSENTIAL GEAR

You're still reading, so we assume you are interested in doing this. The three things you need are: an always-on computer, some suitable software, and a decent amount of storage space. The first one could be any Linux computer you leave turned on, but we are going to use a Raspberry Pi for this [**Image A**]. It's ideally suited for the low-powered, always-on needs of a home network. You may have heard of the software, it's called OwnCloud (www.owncloud.org), and for the storage space, you need to add some to the Raspberry Pi. For initial testing, a decent-sized SD card will give sufficient storage. As your storage needs grow, a USB external disk may be called for.

2 SETTING UP THE PI

We are going to use the latest version of Raspbian on the Pi, although these instructions work with any distro based on Debian, so you could equally follow them on an Ubuntu desktop. Download the latest Raspbian Lite image from www.raspberrypi.org/downloads/raspbian, and copy it to an SD card. Then put in it the Raspberry Pi, and fire it up. Raspbian Lite is a headless version, which means all commands are entered in an SSH session, so open a terminal on your computer, and run:

```
$ ssh pi@IP-ADDRESS
```

using the IP address of your Pi. The default password is "raspberry," so the first thing to do is run:

```
$ sudo raspi-config
```

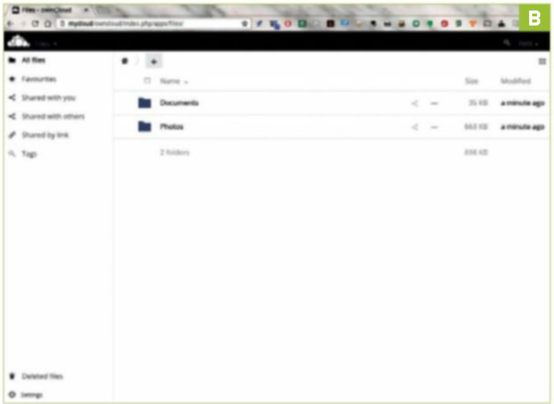
and change the password to something else. Then select the option to resize the filesystem to fit your SD card. You should also go into the advanced options section, and give the Pi a hostname. When you exit raspi-config and reboot, it should then be accessible using the hostname you gave it (although this does depend on your router).

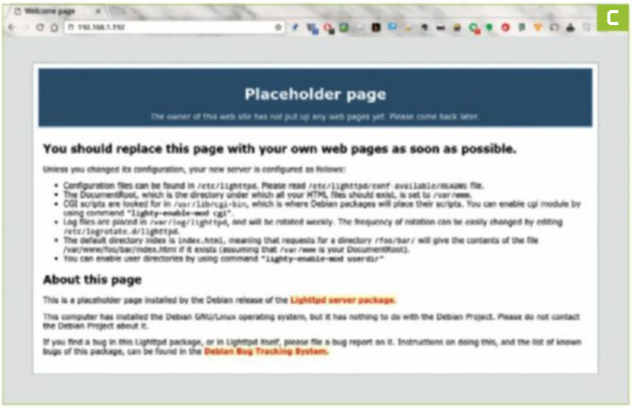
›› Your Raspberry Pi is assigned an IP address by your router's DHCP server. While such addresses are assigned dynamically, DHCP servers generally remember which address they gave to which hardware, and give the same one each time. You can set up your server to use a static IP address, of course, but it's generally not necessary, especially if you set a hostname in raspi-config to give the Raspberry Pi a useful name. This is the local address we are talking about—some sort of static address or domain is needed if you want to be able to connect to your cloud storage from outside of your network. If you don't have a static address, one of the dynamic DNS services would be useful.

3 INSTALL A WEB SERVER

OwnCloud is a web application [**Image B**], so it needs a web server to run it. Apache is the most popular web server, but it's a bit heavyweight for a Pi, especially as we don't need all its capabilities. Lightweight, but very functional, alternatives include lighttpd (www.lighttpd.net) and Nginx (http://nginx.org)—we are using the former here. SSH into your Pi, make sure everything is up to date, then install lighttpd (known to its friends as "lighty"), and the required PHP modules with:

```
$ apt-get update
$ apt-get upgrade
```




C

Welcome page

192.168.1.192

Placeholder page

The owner of this web site has not put up any web pages yet. Please come back later.

You should replace this page with your own web pages as soon as possible.

Unless you changed its configuration, your new server is configured as follows:

- Configuration files can be found in /etc/lighttpd. Please read /etc/lighttpd/conf-available/README file.
- The DocumentRoot, which is the directory under which all your HTML files should exist, is set to /var/www.
- CGI scripts are looked for in /usr/lib/cgi-bin, which is where Debian packages will place their scripts. You can enable cgi module by using command "lighty-enable-mod cgi".
- Log files are placed in /var/log/lighttpd, and will be rotated weekly. The frequency of rotation can be easily changed by editing /etc/logrotate.d/lighttpd.
- The default directory index is index.html, meaning that requests for a directory /foo/bar/ will give the contents of the file /var/www/foo/bar/index.html if it exists (assuming that /var/www is your DocumentRoot).
- You can enable user directories by using command "lighty-enable-mod userdir"

About this page

This is a placeholder page installed by the Debian release of the Lighttpd server package.

This computer has installed the Debian GNU/Linux operating system, but it has nothing to do with the Debian Project. Please do not contact the Debian Project about it.

If you find a bug in this Lighttpd package, or in Lighttpd itself, please file a bug report on it. Instructions on doing this, and the list of known bugs of this package, can be found in the Debian Bug Tracking System.

```
$ apt-get install lighttpd php5-cgi php5-gd php5-curl php5-sqlite
```

›› Now point a browser at http://<IP-ADDRESS-OF-PI>, and you'll see the lighttpd placeholder page [**Image C**]. We'll disable access to this later on, after we've set up the homepage.

›› Now it's time to install OwnCloud, which is basically a case of unpacking the tarball into the web server's DocumentRoot—the directory from which it serves files. In the Raspbian install of lighttpd, this is /var/www/html, so unpack the tarball with:

```
$ sudo tar -C /var/www/html -xf owncloud-9.0.2.tar.bz2
```

4 INSTALLING OWNCLOUD

OwnCloud defaults to storing its data inside its DocumentRoot, which isn't particularly secure. It's safer to create a directory elsewhere for this, and make it owned by the user running the web server—www-data for Debian systems.

```
$ sudo mkdir -p /var/owncloud/data
$ sudo chown -R www-data: /var/owncloud
```

›› The server also needs write access to some directories in the DocumentRoot, which you do with this command:

```
$ sudo chown -R www-data: /var/www/html/owncloud/
{apps,config,themes,updater,.user.ini}
```

›› Don't be tempted to simply chown the whole Owncloud directory; it's more secure if you only allow the web server to write to the directories it needs to. If you try to open http://IP-ADDRESS/owncloud in your browser, you get a "Forbidden" error, so there's clearly some more configuration to do. There are various pre-made configurations in /etc/lighttpd/conf-available. You enable them with the `lighttpd-enable-mod` command, which symlinks them into the conf-enabled directory. Run:

```
$ sudo lighttpd-enable-mod accesslog
$ sudo lighttpd-enable-mod fastcgi
$ sudo lighttpd-enable-mod fastcgi-php
```

then restart the server with:

```
$ sudo systemctl restart lighttpd
```

and reload the page in your browser. Here you are asked to create an admin user and password, Click on "Storage & database" below this, and change the data folder to /var/owncloud/data. After a bit of whirring and clicking (well, the Pi is silent, but that's what it feels like), the OwnCloud homepage shows up. At this point, you can create folders and upload files by clicking the "+" icon above the file list.

›› At the top-right of the display, you will see your username as a drop-down menu. As your user is also the admin, this menu has extra options—for example, you can create users and groups (these are for OwnCloud only, not to be confused with system users and groups). There is also an admin option, and selecting this loads a page with various settings and a couple of warnings at the top. The first warns you that you are using HTTP and not HTTPS to transfer files. This is not a problem if you are only running OwnCloud on your private LAN, and it does make life a little easier for the Pi. If you are sharing files over the Internet, using HTTPS is a good idea, and is covered later on.

5 OWNCLOUD ADMIN

The other warning is about a memory cache. This isn't required, but does speed things up. To set this up, install the APCu (Alternative PHP Cache) program and then restart the server:

```
$ sudo apt-get install php5-apcu
$ sudo systemctl restart lighttpd
```

›› Then enable the cache in OwnCloud by editing /var/www/html/owncloud/config/config.php and adding `'memcache.local' => '\OC\Memcache\APCu` to the end of the file, just before the final closing parenthesis. After editing, the end of the file should look like:

```
'installed' => true,
'memcache.local' => '\OC\Memcache\APCu',
);
```

PICK A DATABASE

As well as a web server, OwnCloud also needs a database. You have two main choices here: MySQL or SQLite. SQLite is simple and lightweight, and perfectly sufficient for a small home setup, and that's what we've used in the instructions here. There are a few reasons for using MySQL instead, however—for instance, you may want a larger setup serving several users, or you are already running MySQL on your computer, in which case, it's more efficient to use a single database server.

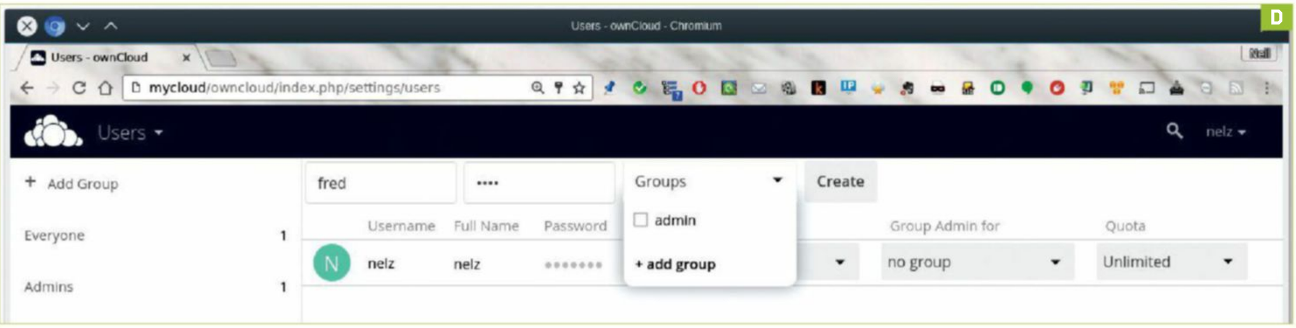
It's also recommended that you use MySQL if you want to use the desktop sync clients. If you want to use MySQL, it's easiest to do this right from the start by running

```
$ sudo apt-get install php5-mysql
```

when you install the rest of the PHP components. If this also installs MySQL for the first time, you are prompted for an admin password for the database—don't forget it. When you load OwnCloud for the first time, the database options include MySQL, where you can pick a database name, along with a username and password. These are used only by OwnCloud for accessing the database—don't use your normal login details. If you start with SQLite, and later decide to switch to MySQL, the OwnCloud command-line tool, occ, has an option to make the conversion for you:

```
$ sudo -u www-data php occ
db:convert-type --all-apps mysql
oc_admin 127.0.0.1 ownclouddb
```

You run it as the user owning the existing database—`--all-apps` simply tells it to convert all apps, not just the enabled ones. The following options are the type of database to create (mysql), the username to admin that database, its IP address, and the name of the database itself. This creates a suitable database in MySQL, migrates your data, and also alters OwnCloud's configuration to use that database.


D
Users - ownCloud - Chromium
Users - ownCloud
mycloud/owncloud/index.php/settings/users
Users
nelz
+ Add Group
Everyone 1
Admins 1
fred
••••
Groups
Create
☐ admin
+ add group
Username
Full Name
Password
Group Admin for
Quota
N
nelz
nelz
•••••••
no group
Unlimited

6 SECURING ACCESS

OwnCloud already has usernames and passwords to control access, but if you are going to open your OwnCloud setup to the world at large, you need to take some extra precautions. First of all, the advice to locate the data directory outside of the web server's scope becomes even more important. If you cannot do this for any reason, you can disable access to it by lighttpd by editing /etc/lighttpd/lighttpd.conf, and adding:

```
$HTTP["url"] =~ "^/owncloud/data/" {
  url.access-deny = ("")
}
```

» This blocks all access to the data directory. Then you should disable all directory listings by adding:

```
$HTTP["url"] =~ "^/owncloud($|/)" {
  dir-listing.activate = "disable"
}
```

» OwnCloud includes an Apache .htaccess file to implement these measures, but lighttpd does not use .htaccess files, so you have to put everything in the configuration file, then restart the server. Many server administrators discourage the use of .htaccess anyway, as it means every page load causes them all to be parsed again, while configuration files load only once at startup.

» The other important step for remote usage is to use HTTPS instead of HTTP. You can do this with a self-signed certificate. First, you need to create a certificate:

```
$ cd /etc/lighttpd
$ sudo openssl req -new -x509 -keyout server.pem -out server.
pem -days 365 -nodes
$ sudo chmod 400 server.pem
$ sudo lighttpd-enable-mod ssl
```

» While you're at it, add HSTS (HTTP Strict Transport Security) by creating the file conf-enabled/10-hsts.conf, containing:

```
server.modules += ( "mod_setenv" )
$HTTP["scheme"] == "https" {
  setenv.add-response-header = ( "Strict-Transport-
Security" => "max-age=31536000")
}
```

» You can change the name and location of the certificate file as long as you edit the setting for sss.pemfile in 10-ssl.conf to match. Using a self-signed certificate causes your browser to warn you, until you add an exception, but if you are only using it to access your own files from outside, that isn't an issue. For more serious use, a proper SSL certificate is a better idea. Once you restart the server, you can access it as https://your.server/owncloud.

» You also have to configure your router to forward the relevant incoming port to your OwnCloud server. This is normally port 80 for HTTP, and port 443 for HTTPS. If you want to enforce HTTPS usage when connecting from outside, only forward port 443 on your router.

» There is another way to handle access from outside: to use a VPN. It is beyond the scope of this article to explain how to do that, but if you regularly connect to your network from outside, running OpenVPN or using a service such as ZeroTier One saves you having to set up and secure for external access for each of your services.

ANOTHER PI TUTORIAL NEXT MONTH

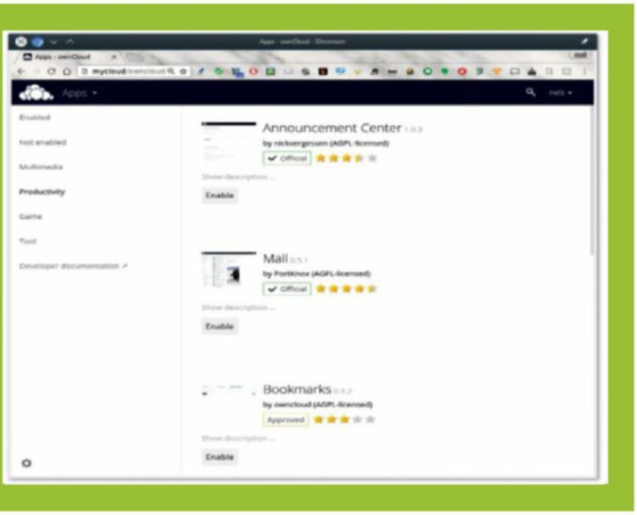
7 EXPLORING OWNCLOUD

So, you have set up OwnCloud, and you can upload and download files, but you could do that with just a web server. What makes OwnCloud useful are its abilities to share files and other data. Click on the drop-down menu by your user name, and go to the "Users" page to create

APPS GALORE

When you went into the Apps section to add the documents app, you may have noticed a lot of other apps. Most of the apps are installed but not enabled. You can either browse the categories, or use the search option to find interesting apps, then you just need to hit each app's "Enable" button to make it available.

The Productivity section includes the usual calendar, contacts, bookmarks, notes, and to-do list type apps, but there are more available, including an email client, so OwnCloud can double as your webmail, too. There is already a photo gallery app in the default OwnCloud setup, but the Multimedia section includes an enhanced option, as well as a music player. All of this can be shared with other users as you desire.


Apps
Enabled
Not enabled
Multimedia
Productivity
Game
Tool
Developer documentation ↗
Announcement Center
Official
Show description ...
Enable
Mail
Official
Show description ...
Enable
Bookmarks
Approved
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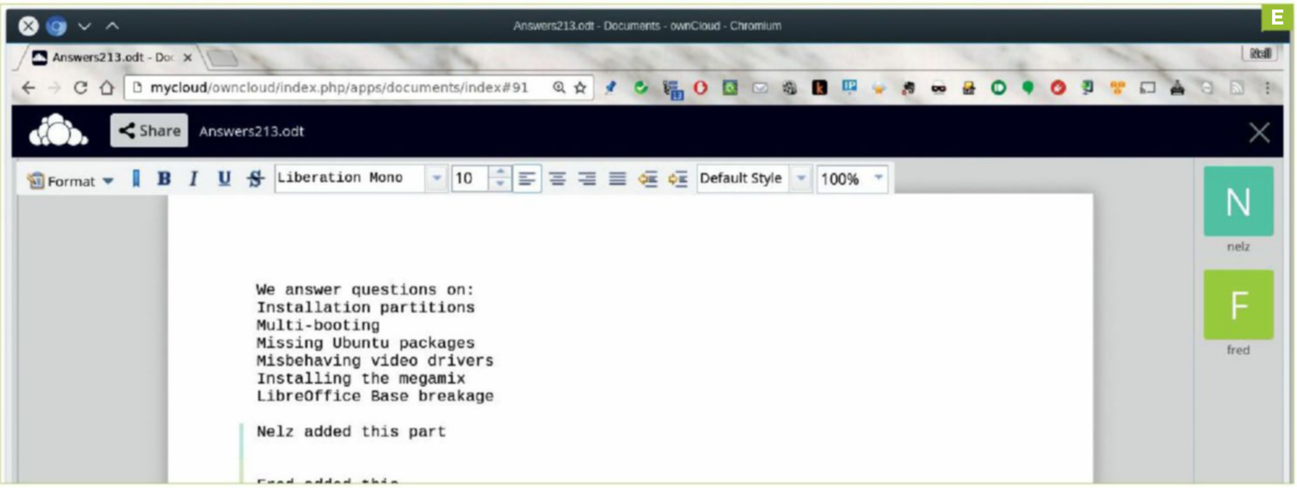

E
Answers213.odt - Documents - ownCloud - Chromium
Answers213.odt - Doc
mycloud/owncloud/index.php/apps/documents/index#91
Share
Answers213.odt
Format
Liberation Mono
10
Default Style
100%
N
nelz
F
fred

```
We answer questions on:
Installation partitions
Multi-booting
Missing Ubuntu packages
Misbehaving video drivers
Installing the megamix
LibreOffice Base breakage

Nelz added this part
```

users and groups. Each user has their own password, and just as with the Linux system, they can be collected into groups. Once you have created a user, you can share folders and files with them. Click on the share icon to the right of the file or folder name to open the sharing pane. Type part of a user or group name to see a list of matches, then select the one you want. It's also possible to share with a user on another OwnCloud server by typing "user@server.address/owncloud." Once you have added a user to share with, a number of checkboxes enable you to specify what they can do with that share: whether they can re-share it with others, and whether they can edit, overwrite, or delete files you created.

» If you just want someone to be able to download a file, without giving them access to the rest of your OwnCloud, check the "Share link" box; this gives you a URL that you can pass to them to view or download the file directly. If you are concerned about others using this link, you can password-protect it or set an expiry date.

8 COLLABORATION

Being able to let others view and upload files is good, but OwnCloud also allows for collaboration [**Image D**]. At the moment, this is limited to word processor documents in ODT, DOC, and DOCX format. The first step is to enable the Documents app: select "Apps" from the drop-down menu at the top-left of the display, type "documents" in the search box, then press the "Enable" button for the app. Go back to the drop-down menu, and you'll see a new option for "Documents." From here, you can open an existing document, create a new one, or upload one from your computer. See the "Share" button at the top of the word processor display? Avoid it, as it doesn't work in the current release. Instead, go back to the "Files" view, and share the file from there. Make sure you enable the "Can edit" and "Can change" options, then each user can open the file in their Documents app, and make changes. As other users edit the file, you can see the changes in your editor, color-coded to show which user made which change [**Image E**].

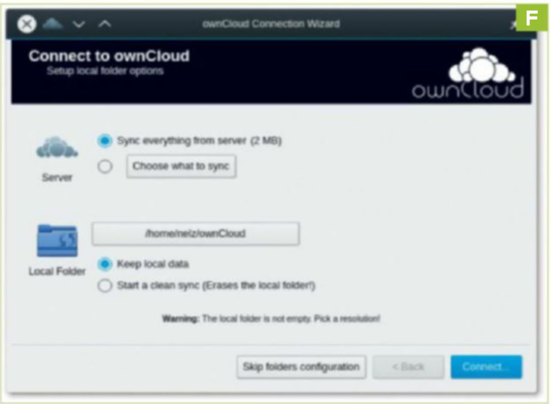
9 KEEPING IN SYNC

Keeping your cloud documents synchronized with your desktop and mobile computers is easy, as there are synchronization programs for the three major desktop operating systems (Ubuntu, OpenSUSE, and Fedora), as well as Windows and Mac, along with mobile apps for various platforms. Install them in the usual way, then add an account with your server address and login details. As with the browser access, if you are using a self-signed SSL certificate, you are asked whether to accept it the first time you connect. Then you can choose which folders to sync between the computer and server. The default is to keep a copy of everything on the server in ~/ownCloud, but you can choose individual directories to sync. You can sync whichever folders you want; there is no arbitrary limit as with most commercially provided servers, especially their free versions. Once set up, the desktop client [**Image F**] sits in the system tray, and notifies you when files are updated. Setting up the mobile clients is similar, but if you want to be able to sync when out and about, you need to set up your router, and OwnCloud, for external access.

» There's a couple of tweaks you may want to make. We mentioned disabling the lighttpd placeholder page: You can delete the index.lighttpd.html placeholder file from the DocumentRoot, then prevent any directory listings of that URL by adding this to /etc/lighttpd/lighttpd.conf:

```
$HTTP["url"] =~ "^/$" {
  dir-listing.activate = "disable"
}
```

» The default maximum file upload size is 512MB, which is possibly sufficient for Internet use, but you may want to exchange larger files over your LAN. You can change the limit in the "File Handling" section of the "Admin" page. If you see a message about missing permissions, make sure owncloud/.user.ini is owned by www-data, and restart the server. It may take a few minutes for this change to take effect. If you start uploading large files, you'll soon fill the Pi's SD card. If you attach a USB hard drive, copy the contents of /var/owncloud/data to the drive, then mount the drive at /var/owncloud/data, you can have as much space as you want. That should get you started with OwnCloud, but there are plenty of other options to explore. ⏻


F
ownCloud Connection Wizard
Connect to ownCloud
Setup local folder options
ownCloud
Server
Local Folder
Skip folders configuration
< Back
Connect...

● Sync everything from server (2 MB)
○ Choose what to sync

/home/nelz/ownCloud

● Keep local data
○ Start a clean sync (Erases the local folder!)

Warning: The local folder is not empty. Pick a resolution!

Build a Level with TrenchBroom

YOU'LL NEED THIS

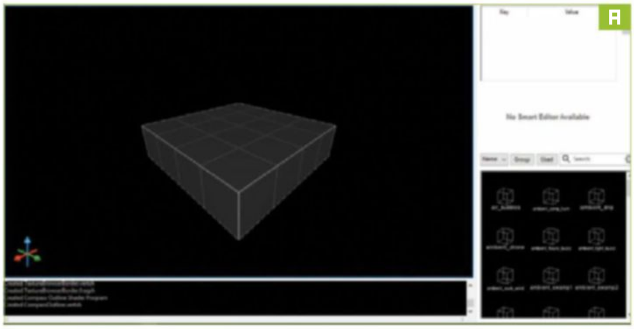
TRENCHBROOM

Download the editor from http://kristianduske.com/trenchbroom.

A MODERN QUAKEWORLD CLIENT

nQuake is our current favorite: http://nquake.com.

Quake's pure brown deathmatch violence is, despite its age, eternal. Even when the FPS genre came of age, and became a hyper-realistic orgy of shiny blood and countless polygons, *Quake's* fast, raw blasting (bar a few resolution, networking, and interface upgrades) stayed static. Not so for its map editors. Where once you were forced to wrap your head around constructing maps using 2D views covering three axes, now, with 3D editor TrenchBroom (plus a bunch of handy textures and some modernized compilation tools), you can do it in a manner much closer to playing the game itself. It's even (whisper it) quite easy. So, let's make ourselves a kickass deathmatch map, and learn about the muddy world of brushes, spawns, and more. Bear in mind that much of this hasn't changed in the intervening years: The techniques we learn here can be applied to later Source Engine games, such as *Half-Life* and *Team Fortress 2,* although the editor can't.... **–ALEX COX**



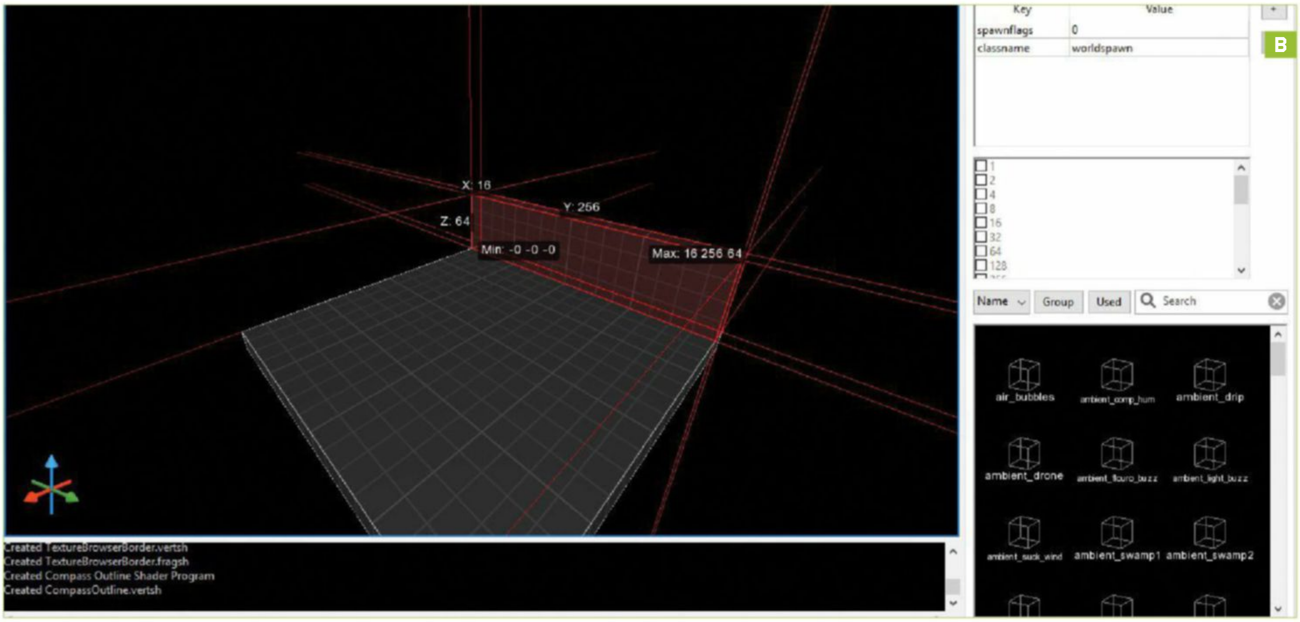
1 FIRST STEPS

TrenchBroom is very much a two-handed editor, as you need to make use of keyboard shortcuts (or a properly configured gaming mouse) to get the most out of it. So, we recommend you start by making sure you're not using a trackpad; while it's possible, it's not pleasant. Grab the latest stable TrenchBroom package from http://kristianduske.com/trenchbroom/ and unzip it directly to c:/trenchbroom—it's a bit finicky about folder names, so make sure you put it in that specific place. Once it's installed and running, go to "View/Preferences," and click "Choose" to set the path to your *Quake* installation.

» The look of the TrenchBroom window on your first run won't give you many clues as to what to do next. You'll see a 3D gray rectangle on a foreboding black background [**Image A**]. But try a few movement techniques: Hold the right mouse button and drag around to freelook, or use WASD to move around, and you'll get an early idea of how easy it is to navigate through your creations.

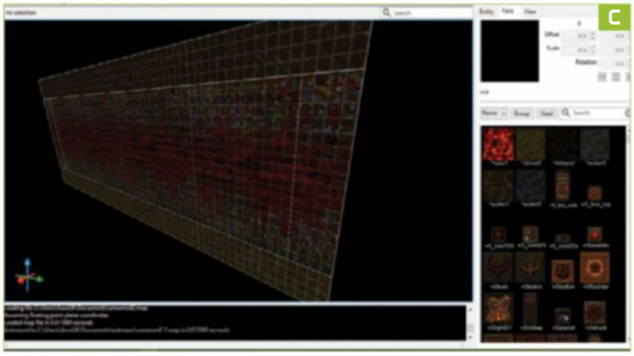
2 BRICKLAYING FOR BEGINNERS

Let's begin by building a wall. Left-click and drag slightly on one of the top corner squares of your existing gray cuboid, and another cube should appear. This is a brush; all of *Quake's* level geometry is made up of brushes. Move your mouse cursor over one of its faces, and hold Shift; the lines on the edge of the face should switch from red to white. Click and drag the face, and you move it,



Key	Value
spawnflags	0
classname	worldspawn

```
Created TextureBrowserBorder.vertsh
Created TextureBrowserBorder.fragsh
Created Compass Outline Shader Program
Created CompassOutline.vertsh
```



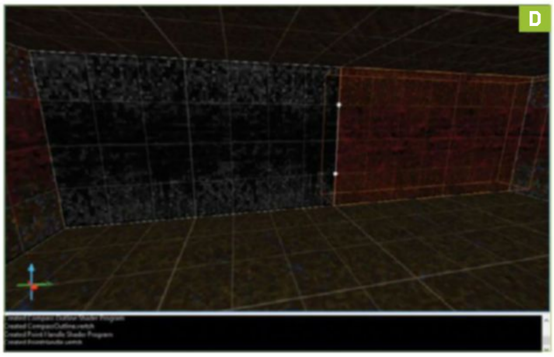
expanding the brush along with it. If you keep Shift held and move to a different face, you can quickly mold a brush the size of a wall.

›› Watch for the values when you hover your cursor over a selected brush, and use them to stretch out your floor brush to 256x256 wide. Use your scrollwheel to zoom out if you can't see far enough. Now use your newfound creation skills to build 64-unit-high walls around each edge [**Image B**]. Bear in mind that you can't create a new brush if there's already one selected, so either left-click the black background, or use Ctrl-Shift-A to deselect everything. Next, select the floor, hold Ctrl and Alt, and drag it upward to create a copy, then use it as a ceiling. Ctrl creates a copy of an object, while Alt locks your mouse movement to the vertical axis.

3 PAINTING THE WALLS (WITH BLOOD)

Now let's add some color to our boring gray boxes. There are various ways to extract *Quake's* textures from your id1.pak file, which we're not going to go into here, mostly because they're very awkward. Provided you own the full version of *Quake*, it's OK to grab the texture wad from a site such as www.bspquakeeditor.com/files/quake_wad.zip, or even use a freeware texture wad.

›› Each time you create a new map, you need to tell TrenchBroom which texture pack(s) you're using. Go to "Edit/Map Properties," click the plus sign below the Texture Wads box, and point it toward your .wad file. Back in the editor, click "Face" near the top-right of the window to bring up the texture browser. Click one of your brushes, then click a cool-looking texture in the browser to paint it up [**Image C**]. The offset, scale, and rotation controls at the top of the texture browser can be used to tweak the orientation of textures; hold Shift, and click on a single face to edit the texture of just that surface.



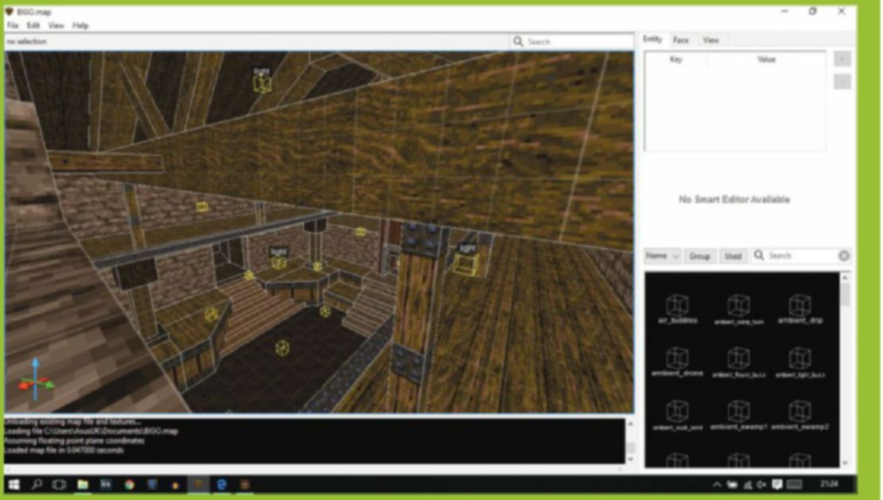
4 CUTTING DEEP

Brushes aren't immutable, and they don't have to be rectangular, either. TrenchBroom includes three alternate editing tools, which enable you to pull off more complex maneuvers. You'll find them in "Edit/Tools," but they're more easily accessible using their keyboard shortcuts. Rotate (R) is fairly self-explanatory; it paints a reticule on to the selected brush, which you can drag to rotate it over three axes. The vertex tool (V) allows for complex manipulation of all the points of a brush, rather than just its faces. But let's look at the clipping tool (C) for now, and use it to cut a door into one of our walls.

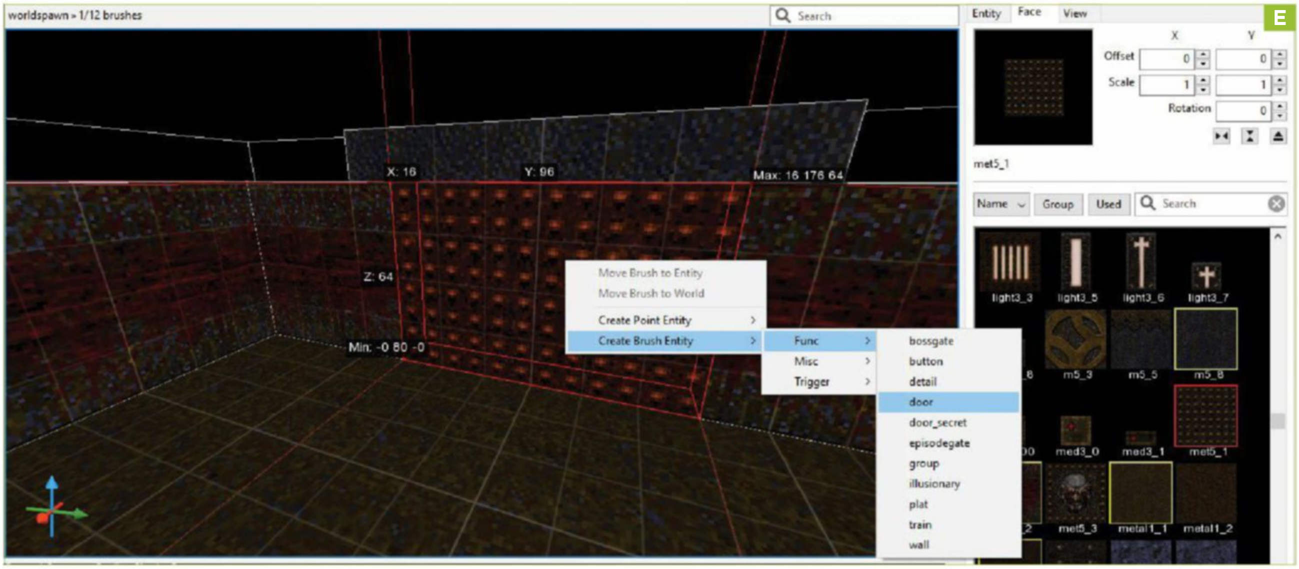
›› Select one of the wall brushes and hit C. It's highlighted in orange—left-click anywhere, and you'll see a vertical line appear, with one half of the block highlighted, and the other not. Click another spot on the wall, and the line intersects the two points [**Image D**]. Hit Enter, and only the previously highlighted part remains. Try it again: Hit Ctrl-Z to undo the last clip, hit C to re-enter clipping mode, then click two points marking one edge of your door frame. Now press Ctrl-Enter twice to change your clipping mode—the

HANDY TRENCHBROOM SHORTCUTS

Navigating TrenchBroom is a lot easier than it first looks, as long as you've got your fingers on the right keys. We know that WASD moves you about, and holding the right mouse button changes the direction you're looking, but try holding middle mouse to pan the camera around, or Alt and right mouse button to orbit the selected brush or entity. If you've selected multiple objects (click each while holding Shift), Ctrl-Shift-C centers the viewpoint on the current selection. Holding Ctrl and clicking and dragging to copy entities and brushes is important, because the copies retain the properties of the original. You can quickly rotate objects in 90º increments using Alt-arrow keys, flip them with Ctrl-F, or delete them by hitting Backspace.



Navigating complex maps is made much easier by the proper keyboard shortcuts.


E
worldspawn » 1/12 brushes
Search
X: 16
Y: 96
Z: 64
Max: 16 176 64
Min: -0 80 -0
Move Brush to Entity
Move Brush to World
Create Point Entity
Create Brush Entity
Func
Misc
Trigger
bossgate
button
detail
door
door_secret
episodegate
group
illusionary
plat
train
wall
Entity
Face
View
Offset
Scale
Rotation
met5_1
Name
Group
Used
light3_3
light3_5
light3_6
light3_7
m5_3
m5_5
m5_8
med3_0
med3_1
met5_1
met5_3
metal1_1
metal1_2

whole of the brush should be highlighted, meaning it will be split, rather than chipped away, when you now hit Enter. Drag the inner edges of your brushes apart to create a doorway, and draw a few more brushes to create a corridor on the other side.

5 BRUSHING UP

Now it's time to get slightly more complex. *Quake's* brushes can be given properties that transform them into entities—essentially, active objects rather than static ones. It's these properties we use to turn brushes into the likes of lifts, teleporters, wind gusts, and doors. So, let's do that now. Draw a brush inside your doorway, texture it as you'd like your door to appear, select it by clicking it, then right-click it. In the "Create Brush Entity" menu, select "Func → Door" [**Image E**], and you'll see a label appear in the 3D view to indicate it's now no ordinary brush.

›› Applying properties to our new door is relatively simple, but this is one area where TrenchBroom doesn't help you out. Select the brush, and select the "Entity" view in the right column—the top box shows that its classname is "func_door" but gives no other clues. So head to the Quake Wiki's entry on func_door (https://quakewiki.org/wiki/func_door) and you'll see a list of keys that can be applied to the entity to specify its behavior. Click "+" to add a property, and write "angle" in the key column. In the value column, insert the value "-1" to make the door open vertically. Try adding other keys to enhance your door further.

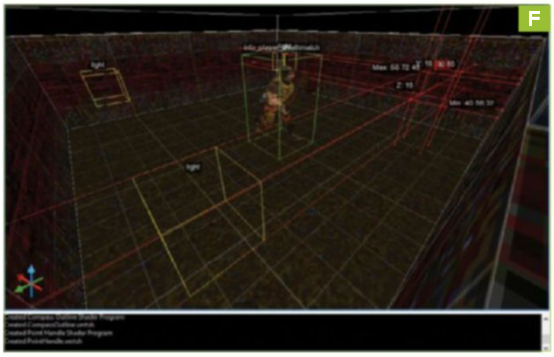
LIGHT IT UP

Lights are funny in *Quake*. The technology of the era—no doubt a cunning hack by John Carmack to suit 486 processors—means there's no active light processing done while the game runs; everything it needs to know about brightness, dark, and shadows is hard-coded into each map at compile time. So, when you add light entities, you need to be careful about how bright they are. Add the key "light" and give it a value—try 100 and go from there—and consider using the "wait" key to set how fast the light decays, useful for creating bright spots without blasting photons all over your map. You may also want to give the map a base brightness beyond pitch black, by adding the command "-light 10" to the light compiler, or not use it if you're just testing the geometry of your level.

6 SEEING THE POINT

Entities don't have to come from brushes, though—point entities allow us to include other non-solid objects in maps, such as weapons, armor, lights, and more. Before we're ready to explore our map, we need to add at least one more entity: a player start point. Select the "Entity" tab in the right-hand column, and scroll through the bottom box until you see the Quake Guy labeled "info_player_deathmatch." Drag this entity into your level, drop it somewhere appropriate, then hit R, and use the rotate tool to point him in the correct direction. Start point entities can also be used as a handy visual marker of scale; if they don't fit in a space, neither will the player.

›› Use the same techniques to place light entities in your level. The red guidelines can help you line up your entities


F
light
light

[**Image F**] if you want accurate, even lighting. See the "Light It Up" box opposite to find out how to make lights look awesome.

7 FROM MAP TO MAYHEM

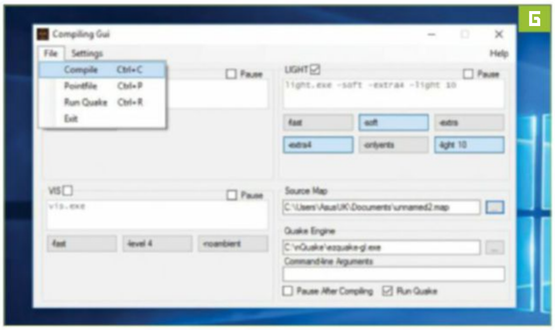
With everything in place, it's a good time to test your map and see how it's all working, so begin by saving it to a folder where you'll be able to find it. To turn a raw map into something *Quake* can use, you need a package of compilers: qbsp, which builds the binary space partitioning files that *Quake* understands; light, which precalculates the level's lighting; and vis, which makes levels faster by splitting them up into chunks—if you can't see part of a vis'ed level, the system won't render it. Grab all these tools in a single package from http://disenchant.net/utils/, and unzip them to a folder. We also highly recommend a GUI such as Necros' Compiling GUI (https://shoresofnis.wordpress.com/utilities/ne_q1spcompilinggui/) to make the process more straightforward.

» Presuming you already have a decent client such as nQuake installed (you should, it's amazing), activating each of the rendering tools in the GUI, bar vis—you don't need it with a map of this complexity—and pointing it to your map, your *Quake* installation, the location of the compiler tools, and leaving the options as they are should get your level up and running. Just hit "File → Compile" [**Image G**] and it'll be built, and *Quake* launched.

8 NEXT STEPS

We've introduced the key principles, but obviously there's not enough space to detail the entirety of *Quake's* internal code. Time for a bit of self-reliance: If you're looking to create something, try replicating the steps we used to turn a world brush into a door brush, but select a different option from the entity list. Don't be afraid to hit up the Quake Wiki or hammer Google for information about configuring specific entities, and check TrenchBroom's excellent and comprehensive help file if you get stuck using its interface. We are fully aware that a vast number of online *Quake* resources no longer exist, but it's 20 years old; the Wayback Machine (http://archive.org/web/) might help if you're really stuck.

» Finally, if you're looking to make a single-player level, just add enemies in the same way as you added the deathmatch start point, positioning and rotating them to where you'd like them spawned, and don't forget to add a player_start entity where you'd like your hapless victim to begin their punishment. Good luck and happy building!


G
Compiling Gui
File
Settings
Help
Compile Ctrl+C
Pointfile Ctrl+P
Run Quake Ctrl+R
Exit
Pause
fast
soft
extra
extra4
onlyents
light 10
fast
level 4
noambient

LIGHT ☑ ☐ Pause

```
light.exe -soft -extra4 -light 10
```

VIS ☐ ☐ Pause

```
vis.exe
```

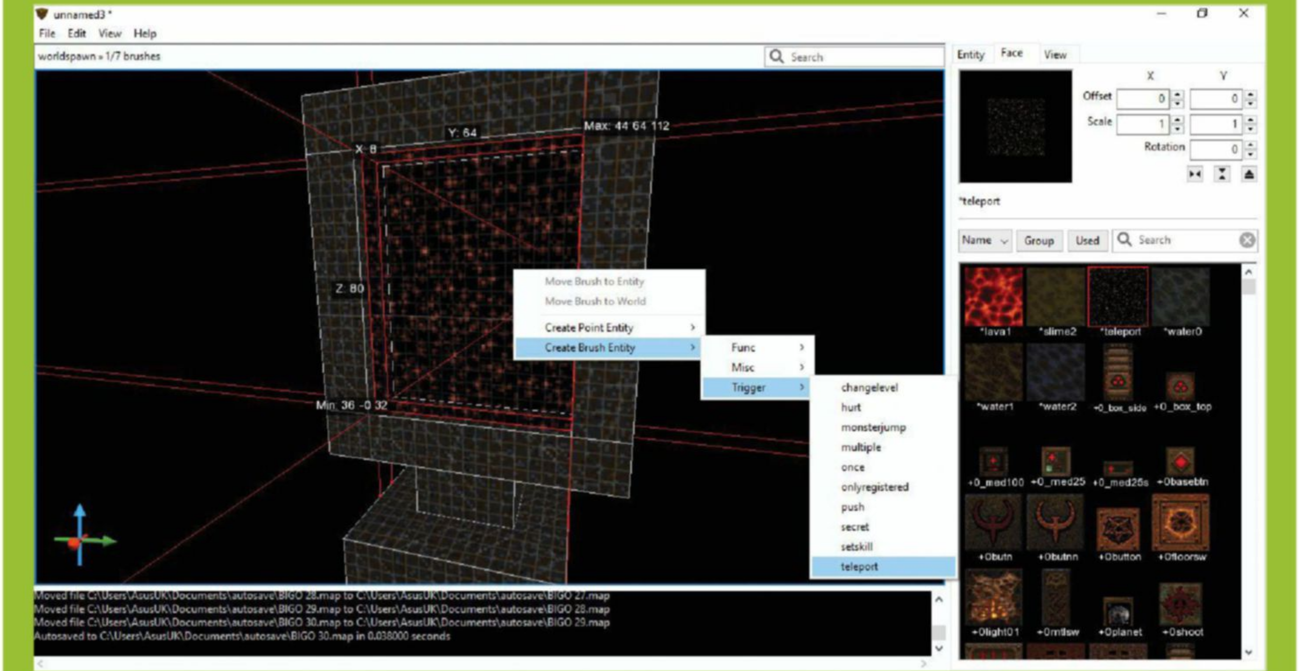
Source Map: C:\Users\AsusUK\Documents\unnamed2.map

Quake Engine: C:\nQuake\ezquake-gl.exe

Commandline Arguments:

☐ Pause After Compiling ☑ Run Quake

MAKE A TELEPORTER


unnamed3 *
File Edit View Help
worldspawn » 1/7 brushes
Search
Y: 64
X: 8
Max: 44 64 112
Z: 80
Min: 36 -0 32
Move Brush to Entity
Move Brush to World
Create Point Entity
Create Brush Entity
Func
Misc
Trigger
changelevel
hurt
monsterjump
multiple
once
onlyregistered
push
secret
setskill
teleport
Entity
Face
View
X
Y
Offset
Scale
Rotation
*teleport
Name
Group
Used
Search
*lava1
*slime2
*teleport
*water0
*water1
*water2
+0_box_side
+0_box_top
+0_med100
+0_med25
+0_med25s
+0basebtn
+0butn
+0butnn
+0button
+0floorsw
+0light01
+0mtlsw
+0planet
+0shoot

```
Moved file C:\Users\AsusUK\Documents\autosave\BIGO 28.map to C:\Users\AsusUK\Documents\autosave\BIGO 27.map
Moved file C:\Users\AsusUK\Documents\autosave\BIGO 29.map to C:\Users\AsusUK\Documents\autosave\BIGO 28.map
Moved file C:\Users\AsusUK\Documents\autosave\BIGO 30.map to C:\Users\AsusUK\Documents\autosave\BIGO 29.map
Autosaved to C:\Users\AsusUK\Documents\autosave\BIGO 30.map in 0.038000 seconds
```

Quake's teleporters are weird, but they're easy to build once you've caught on to the trick. Draw a brush where you'd like the portal to be, right-click it, and turn it into a trigger_teleport, adding the key "target," with a value of your choice. Stick an info_teleport_destination point entity where you'd like the teleporter to fire the player out, and give it a "targetname" key, with the same value you assigned the teleporter brush. Set its rotation so you get a smooth transition. The final step is to draw another brush completely overlapping the original teleporter brush, giving it the "*teleport" texture. Without this last step, your teleporter is invisible—useful for sneaky tricks, but it goes against *Quake* convention.

Handle Videos in Lightroom

YOU'LL NEED THIS

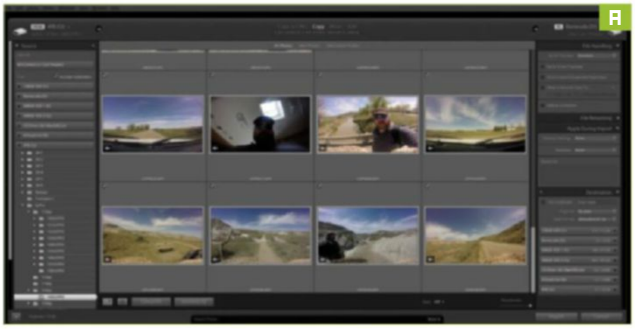
ADOBE LIGHTROOM
Subscribe at www.adobe.com.

VIDEO FILES
Most common file formats are compatible with Lightroom.

LIGHTROOM IS FOR RAW IMAGE WORKFLOW, non-destructive image-editing, and searching, tagging, and organizing. It does those things very well, but there are also some lesser-known tricks up its sleeve, including the ability to deal with video files.

DSLRs have been able to shoot HD video for some time now, and 4K is beginning to make its way into manufacturers' top-level offerings. Lightroom is capable of working with most common video file formats, though, so whether you're using a GoPro, an iPhone, or a Canon EOS 1-DX Mark II, it'll be able to handle the files.

You can import video at the same time as still images, process it in the same app, and organize it into the same folders. However, your options for video are more limited than for editing still photos, because Adobe holds back the advanced features for its dedicated editing apps, such as Premiere Pro. But if you're not prepared to invest in Premiere, Lightroom does a good job. –**IAN EVENDEN**



1 IMPORT VIDEO

Importing your video is achieved in exactly the same way as importing still photos. We've got some GoPro footage that we've already copied to an external hard drive, so when we import it into Lightroom, we're going to choose the "Add" option at the top of the "Import" interface. Doing this leaves the files where they are, and adds them to the Lightroom catalog. Life's too short to wait for gigabytes of video footage to copy over to an internal drive when it's perfectly happy where it is. If we'd got the camera's memory card inserted, however, we would use the "Copy" option [**Image A**], which would transfer the files to a target drive and into a folder hierarchy we'd previously set up. The "Move" option does the same thing, but deletes the files from the source card as it does so—something that sets our Spider Senses tingling as possibly dangerous. *Maximum PC* believes in keeping backups.

2 WAIT A BIT...

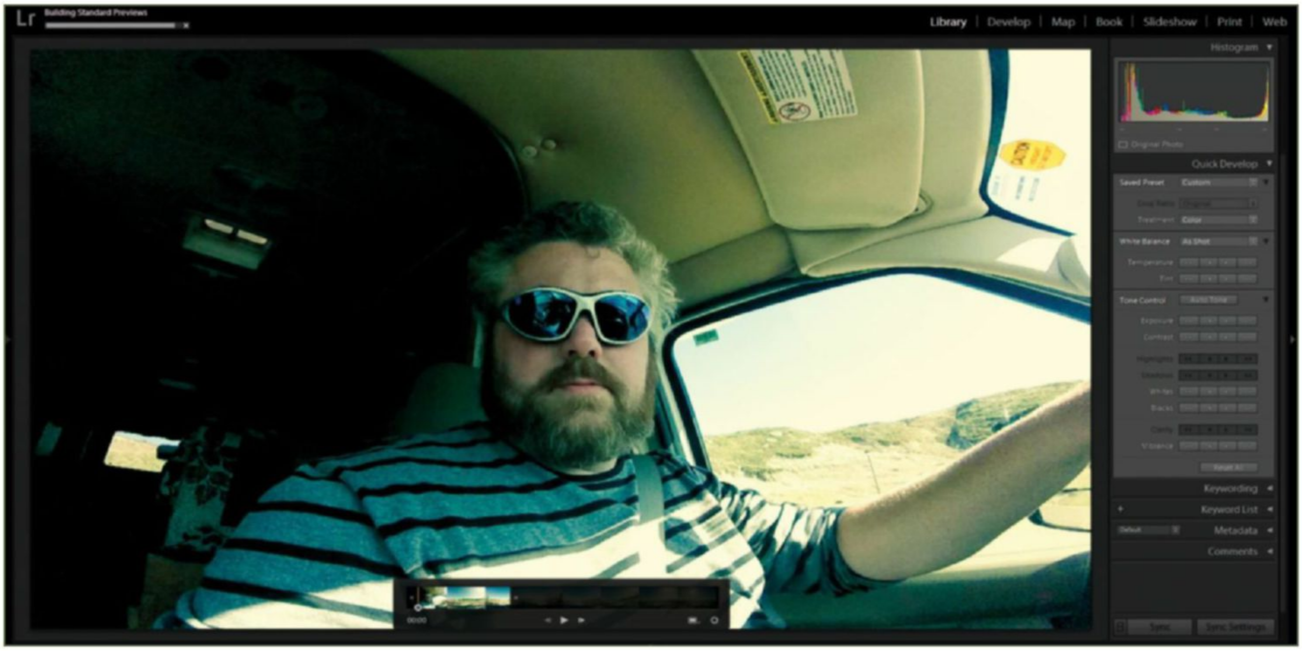
Once you've imported your video, Lightroom takes an inordinately large amount of time creating previews. This takes much longer than the same process does with still photos, and you can understand why when you see that you can pass your mouse pointer across each thumbnail in Library view, and see it change as if you were scrubbing through the file. Our quad-core i7 chugged away for ages on this task, and it was only 182GB of footage. Luckily, you can still carry out other tasks while it's processing.

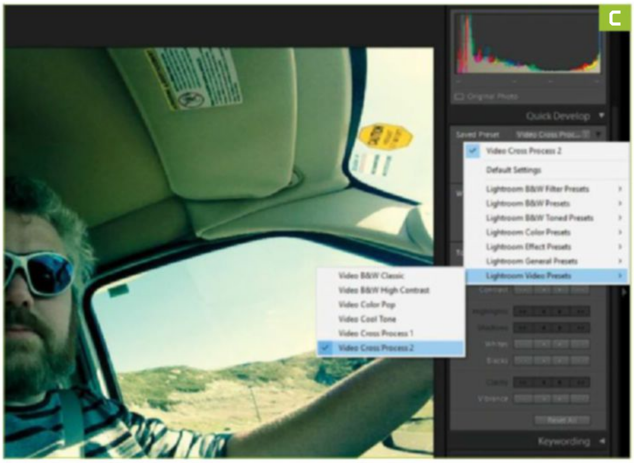
3 FILTER YOUR LIBRARY

If you've told Lightroom to slurp the whole content of a memory card on to your hard drive, you can end up with a Library folder that shows both still photos and videos. There's a simple way to focus on one or the other: a Library Filter. At the top of the interface, you'll see the initial filter options: Text, Attribute, Metadata, or None. Click "Attribute," and at the far-right you'll see a section marked "Kind." Here you can choose to show Master Photos, Virtual Copies, or Videos. They're toggle switches, so you can click as many as you like at once, clicking them again to remove them from the filter. Clicking "Video" does exactly what you'd expect: removes anything that's not a moving picture from your Library view. Click the drop-down menu above these options, and you can make a new filter preset that will make the process faster in the future.

4 LIGHTROOM LIMITATIONS

Once you've chosen your movie file, double-click it so it opens in the Loupe view. You can't take videos into the Develop module, which is a real shame—you can try, but all you end up with is a gray screen with a message on it, telling you that you can't. Instead, you can use the Quick Develop controls just as you would on a photo. There aren't very many of them, but you can adjust a few things about your video.


Library | Develop | Map | Book | Slideshow | Print | Web
Histogram
Quick Develop
Keywording
Keyword List
Metadata
Comments


C
Quick Develop
Video Cross Process 2
Default Settings
Lightroom B&W Filter Presets
Lightroom B&W Presets
Lightroom B&W Toned Presets
Lightroom Color Presets
Lightroom Effect Presets
Lightroom General Presets
Lightroom Video Presets
Video B&W Classic
Video B&W High Contrast
Video Color Pop
Video Cool Tone
Video Cross Process 1
Video Cross Process 2
Keywording

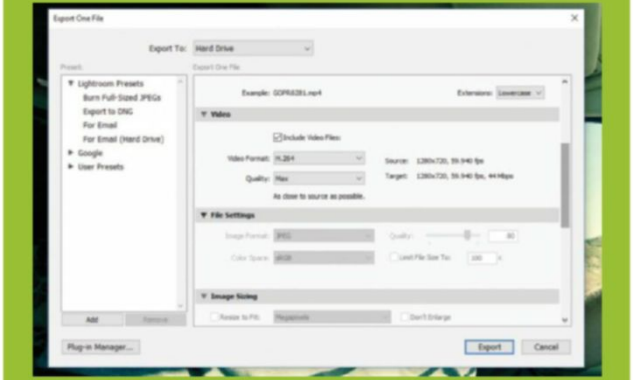
5 TRIM YOUR FOOTAGE

Lightroom's ability to trim your videos is a useful one. Before importing into a serious editing application, you can remove the bits where you fiddled with the camera position or shouted at the sound recordist before things started in earnest. As soon as you open a video in the Loupe view, a bar with play controls appears at the bottom. To the right of this is a cogwheel icon that looks as though it should be some sort of settings menu, but it isn't. Clicking it opens up the trim controls, so you can lop off the beginning and end of your clip. The bar widens to show thumbnails of your clip, and bars appear at either end. Drag these toward the center until only the part you want to keep is unaffected by their gray overlay [**Image B**]. Now, when you export your clip, only the part you selected is saved out. The master copy in Lightroom is, of course, untouched, so you can always come back and chop another part out of a clip if you need to.

6 TWEAK THE LOOK

Finally, you can use the Quick Develop panel to adjust the look of your clip. You can alter the white balance, the tone of the footage, and use presets [**Image C**] to get the look you want. This isn't color grading or anything a professional would use, but if you want to make the colors in a short clip pop, it gets the job done. You can alter the exposure, vibrance, and contrast of the footage manually, too, although it's nowhere near as involved as it would be using the Develop module, because you're using buttons rather than sliders. And, as much as we wished for it, there's no way of removing a GoPro's slight fisheye look in Lightroom. This single addition would make the application's video capabilities a lot more useful! ⏻

EXPORTING YOUR CLIPS


Export One File
Preset:
Lightroom Presets
Burn Full-Sized JPEGs
Export to DNG
For Email
For Email (Hard Drive)
Google
User Presets
Add
Remove
Video
File Settings
Image Sizing
Plug-in Manager...
Export
Cancel

Export To: Hard Drive

Extensions: Lowercase

☑ Include Video Files:

Video Format: H.264

Quality: Max

As close to source as possible.

Source: 1280x720, 59.940 fps

Target: 1280x720, 59.940 fps, 44 Mbps

Video export options are limited to the codec—including the DPX format common in the Digital Intermediate process—and the quality. Otherwise, it's identical to the still photo export process, in that you choose the location, filename, and metadata settings, before letting the app go to work. If you're saving clips for later editing, there's no real reason to do anything but keep the codec the same as it was at import, to save time, and the quality at Max, which keeps it at the same level at which it was shot. Transcoding a video takes time, so the less work you give Lightroom to do, the less time you have to wait. It applies your trims and Quick Develop settings, and you're left with a new file ready for the next stage.

BUILD IT

ZAK STOREY, STAFF WRITER

Mini ITX Budget HTPC

This month, we're on the hunt for a device that reaches the heavenly heights of headless home theater

LENGTH OF TIME: **1–2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

IT'S GOOD TO STEP AWAY from the rig once in a while. To spend time with the family, sit down, and enjoy a bit of televisual entertainment. After all, there's more to the world than pixels and digitized avatars waiting to be quashed. There's a whole variety of delights to watch, with real people, in the comfort of your own couch.

So, what's the plot of this particular tale? We want to build a small form factor, headless, home theater PC, redesigned for the digital age (sans 5.25-inch drive bay), capable of streaming content over a wireless or wired network, anywhere in the home. Because, when all's said and done, in the age of Netflix, Prime Video, Hulu, and all manner of other digital streaming services, there's really no excuse not to be streaming content direct to your big-screen TV. It's easy, it's convenient, and it doesn't tie you into any unnecessary cable packages or cumbersome Blu-ray drives.

But, let's face it, you can already enjoy that, thanks to the likes of Nvidia's Shield console or the increasingly popular Android TV boxes. It's the versatility of the Windows PC platform that we're after here, though. After all, we stream, we game, we work, and we network on the platform. We should be able to watch movies and TV in comfort, too.

THE SPECS

THIS BUILD was all about the chassis: the Fractal Design Node 304. It's an ITX beauty, capable of housing a serious amount of heft. To minimize our budget, though, we went with an Intel Pentium G3258 Anniversary Edition dual-core processor, clocking in at 3.2GHz, with 16GB of low-profile DDR3 at 1,600MT/s, a 650W PSU (a little overkill), a 120GB SSD for the boot drive, and 2TB of old-school storage for all our media. It's worth noting that the motherboard we actually put into action is the Gigabyte Z97N Gaming 5, which is unfortunately now only available for $300 on Amazon, used. But as the motherboard isn't going to add much in the way of performance, opting for an alternative, cheaper, H97 board instead is fine.

We stuck with the retail cooler—unless you're planning on overclocking the Pentium G3258, you can get away with retail, and due to the lack of internal componentry involved, the two 92mm intake fans at the front of the chassis, and the rear 120mm, is plenty.

So, a scraping together of spare parts? Sort of. That's the beauty of having older hardware lying around. However, if you were looking to do something similar with the Z170 chipset, we suggest opting for a low-end Intel Pentium G4400, a Samsung SM951 for boot drive, and a Gigabyte GA-Z170N ITX motherboard or equivalent (remember to make sure it supports the M.2 connection standard).

INGREDIENTS

PART		STREET PRICE
Case	Fractal Design Node 304	$90
Motherboard	Asus H97I Plus	$150
CPU	Intel Pentium G3258 AE	$67
Memory	Crucial Ballistix Sport DDR3 @ 1,600	$70
GPU	Intel HD Graphics	$0
PSU	Corsair RM 650X	$110
Storage 1	Kingston SSDNow V300 120GB	$43
Storage 2	Hitachi Ultrastar 2TB HDD 7,200rpm	$45
Total		$575

1

DDR AND PROCESSOR CHOICES

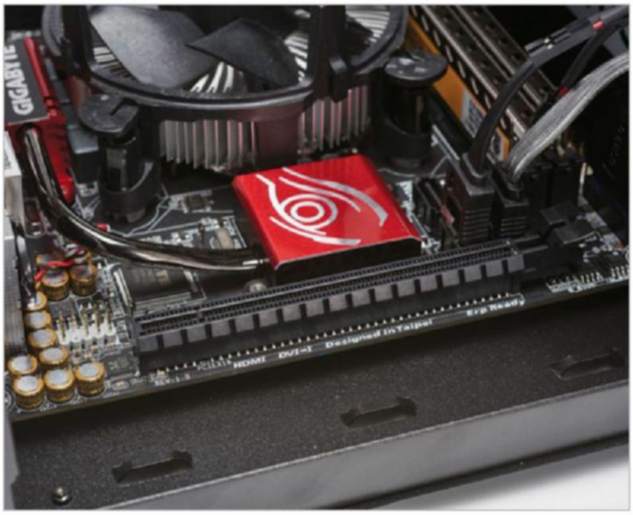
IN A BUILD like this, processor choice is one of the few decisions you're going to have to make early on. The Intel Pentium G3258 AE is a marvel, capable of punching out hefty overclocks up to 1GHz over stock—if you've got the cooling capacity. The retail cooler leaves quite a bit to be desired, but finding suitable cooling solutions in the Node 304 is challenging. Even Corsair's compact Hydro AIO doesn't quite fit here. But this is a very basic home theater/streaming PC, so do you really need the extra grunt in a machine like this? On top of that, you have to consider what RAM you're going to use. We decided to crack out this set of Crucial super low-profile DIMMs, providing us with 16GB of DDR3. They're a little antiquated by today's standards, but are still overkill for what we intend to do with this build.

GIGABYTE
intel

2

PCIE WOES

SO, THE ITX FORM FACTOR, while pleasingly compact for our aesthetic requirements, allows itself the luxury of just one PCIe slot. That's enough for one graphics card, a soundcard, or some form of PCIe add-in card. Unfortunately, the Fractal Node case doesn't give you much in the way of room for maneuver. Once you have the power supply installed, along with a couple of hard drives, fitting a GPU around the cables in the Fractal Node is damn near impossible. In fact, this is the only time that we've found a suitable application for the tiny footprint of AMD's R9 Nano. The reason we bring this up is mostly down to the troubleshooting we had to go through just to get that Pentium G3258 to work once the system was put together. But we'll touch on that in the conclusion....



3

POWER SUPPLY PROBLEMS

AS YOU CAN SEE, this build is messy. Very messy. Unfortunately, the Node's low-slung design leaves little room for any form of cable management. Even with an infinite number of cable ties, it's a struggle to tidy this up effectively. And that's not the end of the problems: If you ever fancy transforming this spec into a gaming system, your GPU choice is going to be substantially limited. In fact, in a lot of ways, you'd be better off purchasing a non-modular PSU. The reason we say this is because most non-modulars have all their cables bunched up in one corner—as opposed to laid out and nicely organized along the back of the power supply—which saves space, and hopefully helps you install your GPU with as little trouble as possible.

4

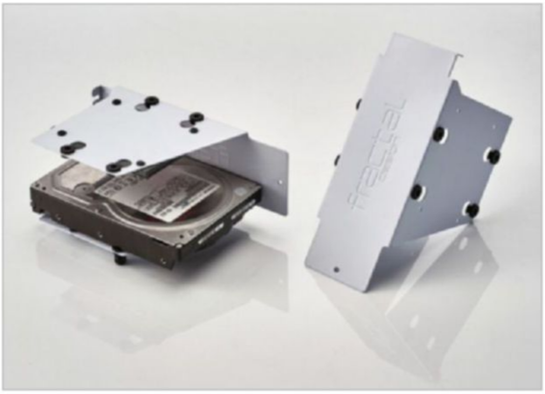
PASS-THROUGHS AND COOLING

BECAUSE THE POWER SUPPLY is situated at the front of this build, we have to make do with a substantial pass-through, heading along the side of the case. It doesn't cause much in the way of problems, but it's worth remembering that you'll need to leave the power switch on here before closing up your chassis. There's nothing worse than closing up a chassis, plugging everything in, and then scratching your head, wondering why it isn't powering up. Also, you can just about glimpse those dual 92mm intake fans at the top there. They're mighty quiet for fans of this size, yet still provide plenty of oomph when it comes to internal cooling.

5

HARD DRIVE CADDIES

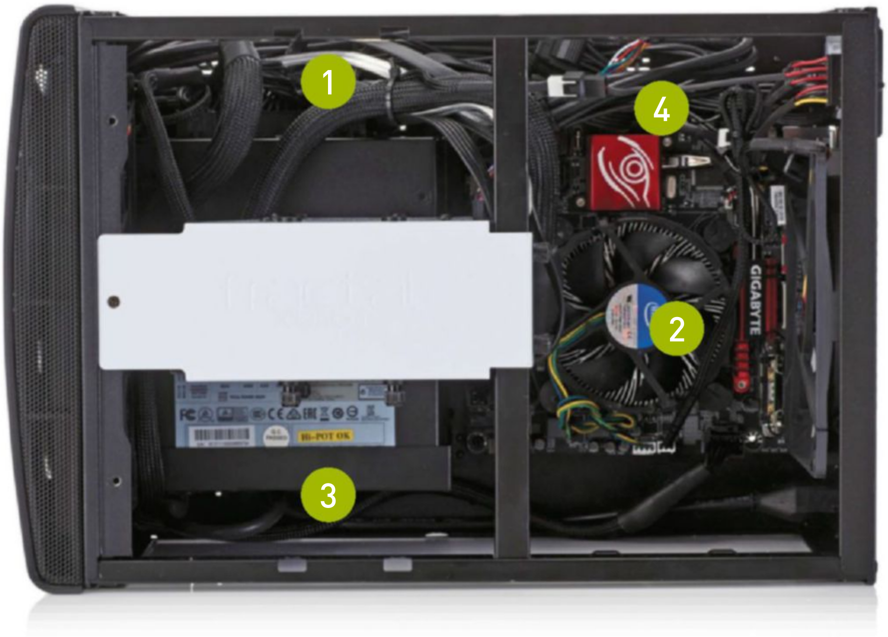
ONE OF THE NEAT FEATURES Fractal included in the design of its Node 304 is these sweet little drive cages. Capable of mounting two drives in each, these sit snugly in the top of your chassis, along a cross member support pole. Three come as standard with the case; we opted to use one, and slapped it right in the middle, between the two fans, and removed the two extraneous cages to improve internal airflow. Each caddie comes with rubber grommets for spinning hard drives, and traditional mounting points for SSDs. Just remember to orient your drives the correct way round when installing them, so your connectors are facing away from the end of the Fractal logo.



6

EVEN MORE COOLING

THAT'S ONE MEATY 140mm fan in the back of the chassis. We reoriented it so it's drawing air into the chassis, as opposed to pumping it out. Ideally, it may have been better to see whether we could attempt to mount a single AIO cooler in here, but to keep the cost down, we opted to go with the retail cooler instead. There's also an exceptionally simple fan controller located on the top-right, too, just above the PCIe brackets. It comes with three settings—low, medium, and high—and three headers internally, for the three fans powered by a single Molex adapter.



1 **This cable management hell wasn't particularly enjoyable to work on. In fact, a non-modular PSU might have provided us with more room to maneuver.**

2 **Fitting an AIO cooler to replace the stock one might have been a good move, especially if we were overclocking, but it would have ramped up our budget significantly.**

3 **Pass-throughs are certainly handy in a chassis like this, but for the sake of a GPU, we would have loved to see the pass-through on the other side, and the PSU reversed.**

4 **Molex—why, oh why do you exist? No, really. Plugging the Molex power into the fan controller here was a total nightmare.**

STREAMING PC SUCCESS?

SO, HAVE WE ACHIEVED a system capable of streaming content across wireless networks at HD and UHD? Yes. Amazon Prime, Netflix, and YouTube all work seamlessly at 2560x1440, delivering top-notch content in your own home. The Pentium G3258 is fairly beefy when it comes to streaming content at this resolution, and in everyday desktop operation, there's very little difference between this and the likes of an Intel Core i7. However, we live in the age of 4K TV—1080p is the new CRT, and a maximum resolution of 60fps 1440p just doesn't cut it.

Your best bet for a 4K streaming rig is to opt for more modern hardware in the form of Skylake and the Z170 chipset. We had a soft spot for the Pentium G3258, due to its overclocking capabilities. Even so, you can add all the MHz in the world, but if the chipset and integrated GPU don't stack up, what's the point? We should have opted for one of Intel's newer G4400 Pentium dual-core CPUs. You could put together a similar system using more modern components for around the same price, at a spec that would make mincemeat of 4K streaming. Hardware struggles to hold its value second-hand, yet as a year or two passes, it becomes far more expensive to buy brand new—just take a look at the Gigabyte Z97N Gaming 5. You could forge a system out of spares and old components (which is what we're trying to suggest), but you'll be far better off opting for newer in-stock componentry, as opposed to buying out-of-date hardware.

The build process was excruciatingly frustrating—impressive, when you consider how little there is in the system. The RM650X, although fantastically quiet, doesn't do so well in a small form factor case. And the lack of cable management space really did a number on us. This case would've worked much better if the power supply orientation was reversed, and the power pass-through located on the side of the PCIe slot, so we would have the choice of installing a GPU if we wanted.

On top of that, during installation of the OS we encountered numerous problems, mostly due to an uncleared motherboard leading to a multiplier of 46 being applied to the G3258 core. Amazingly, even at 4.6GHz, it was stable, but the temperatures kept ramping up when we tried to extract zipped files, to the point that the system would hard reset to protect the core. On top of that, fast-boot was enabled, and getting into the BIOS without a dedicated GPU was nigh-on impossible. In the end, we had to use Intel's Extreme Tuning Utility, and install a spare GPU in the form of the R9 Nano to get back in.

In hindsight, we would have loved to have gone for a more impressively specced Skylake rig, but for a system that we pieced together out of spare parts and older components, it shows just what you can do with old tech.

As a final disclaimer, we should point out that this isn't going to break any records when it comes to benchmarks—it's not meant to. It's a perfect office PC, a system for your grandma, or a home theater. Not a bank-busting, frame-rending, zero-point-shredding machine. ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi Thread	987	226 (-77%)
Cinebench R15 Single Thread	196	117 (-40%)
TechARP's x264 HD 5.0.1 (fps)	21.93	6.28 (-71%)
PC Mark 8 Creative	7,675	2,864 (-62%)
CrystalDisk Sequential Read (MB/s)	1,895	508 (-73%)
CrystalDisk Sequential Write (MB/s)	949	107 (-88%)
Rise of the Tomb Raider (fps)	41	2 (-95%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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INTEL NUC KIT NUC6I7KYK PAGE 78

Intel NUC Kit NUC6i7KYK

Reaching for the stars from the tiniest of platforms

THE NUC (Next Unit of Computing) felt like it was on the cusp of greatness when it was first introduced in 2013. Three and a bit years on, and that feeling still prevails, even though this version looks like a completely different beast from what has come before. For some, this is going to be the perfect tiny PC. Unfortunately, that niche is very tightly defined, and it's still not the mass-market machine many of us were hoping for.

So let's get that spoiler out of the way—this isn't a Kick Ass device. It almost could be, but there's a couple of things holding it back. But before we get to what they are exactly, it's worth covering what you'll find inside Intel's latest barebones system, how Intel is pitching it, and who exactly should be excited by this little box of tricks.

This is a very different-looking device to the NUCs that we've seen before. Instead of the boxy look we have come to expect from the NUC brand, we instead get a much thinner, wider chassis. It's a tad more shapely, too, with chamfered corners and a pleasing hexagon texture here and there. In case you hadn't noticed, there's also a skull on the top—something that alludes to its gaming aspirations. There is an alternative plate in the box that lacks this teenage iconography, if it's a real turn-off. You'll find a VESA mounting plate to hide the device out of sight, too.

This latest NUC is built around an impressive chip—the Intel Core i7-6770HQ. That's a quad-core processor (with HyperThreading, of course), nominally operating at 2.6GHz, but capable of turboing up to 3.5GHz when pushed. It has a TDP of 45W, which is 30W more than the other sixth-gen NUCs, due to the fact it boasts something a little special on the integrated graphics front: the Intel Iris Pro Graphics 580, the company's top-tier GPU. With 72 execution units purring along at 1,000MHz, and laying claim to 128MB of eDRAM to help keep things running smoothly, this core is capable of 1.152TFLOPS. Not bad for integrated graphics.

BUILT TO ORDER

It's important to note that, like its forebears, this is a barebones system. You need to add your own memory (there are two DDR4 SO-DIMM sockets, supporting up to 32GB of 2,133MHz RAM), and your own M.2 SSDs (there are two Type M connectors as well). Plus, you need an operating system. For testing purposes, the machine we reviewed shipped with a 512GB Samsung 950 Pro NVMe SSD, and 32GB of DDR4. While these will definitely add to the cost of the machine, they also give this little system the best chance to impress.

If this all sounds quite promising, then the good news is that when it comes to more serious work, it's a great little machine. For a device this tiny, it's pretty incredible. The Core i7-6770HQ is a powerful chip, as can be seen by the Cinebench and X264 benchmarks. The speedy SSD makes for a fast booting machine, apps launch quickly, and the general feeling in Windows 10 is brilliant. Indeed, were it a little more affordable ($650 for the barebones unit, plus SSD, RAM, and OS soon heads over $1,000), we'd be tempted to forgive it its foibles, but as it is, we can't quite bring ourselves to do so.

The big problem is gaming. Single digits in modern games clearly shows that even Intel's most powerful GPU can't handle the latest titles. You can reduce settings, but even that won't make for a great experience—we ran *Rise of the Tomb Raider* at 1080p, with the settings as low as possible, and hit an average of just 16fps. Older games fared better, with the likes of *Bioshock Infinite* managing 26fps, but you'll have to butcher the settings to get

BENCHMARKS

	ZERO-POINT	
Cinebench R15	682	711 (4.3%)
x264 HD 5.0 (fps)	15.17	15.6 (2.8%)
PCMark 8 Accelerated	6,180	3,646 (-41%)
CrystalDiskMark 4K Read (MB/s)	44.2	54.56 (23.4%)
CrystalDiskMark 4K Write (MB/s)	162.1	186 (14.7%)
Far Cry Primal (fps)	37	8 (-78.3%)
The Division (fps)	33	9 (-72.7%)
Rise of the Tomb Raider (fps)	42	9 (-78.5%)
3DMark Fire Strike	6,583	1,927 (-70%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

For our zero-point we've used a laptop: the Asus G752VT, with a Core i7-6700HQ, 16GB DDR4-2133, 128GB PM951 NVMe SSD, GeForce GTX 970M, and Windows 10 64-bit. All games run at Ultra settings at 1920x1080.

It's a barebones kit—you can tell from the skull.

the likes of *GTA V, Shadows of Mordor,* and *Metro: Last Light* to run smoothly.

The traditional response at this point would be to say that this machine isn't really aimed at the gaming market. The problem is, it definitely is. Intel is pitching this NUC at would-be gamers—with the claim that it'll run modern games at 1080p, in fact. It also helps explain that skull motif. It's damned by Intel's own marketing.

There is a solution to its gaming shortcomings in the form of the Thunderbolt 3 port, which can be used to hook the unit up to an external caddy, such as the Razer Core external graphics card enclosure, but that is an extra cost on top of what is already a pricey build. With Nvidia's mobile take on Pascal imminent, it feels as though this is a solution to a problem that won't exist in a month's time—this unit with a mobile GeForce GTX 1080 would just be a far better solution.

Overall, the latest NUC is an impressive device on many, many levels. But it struggles at one of the things that it was designed to master—gaming. If you like your gaming simple, though, need a powerhouse in a small form factor, and don't mind paying over the odds, there's a lot to love right here. **–ALAN DEXTER**

VERDICT
7

Intel NUC Kit NUC6i7KYK

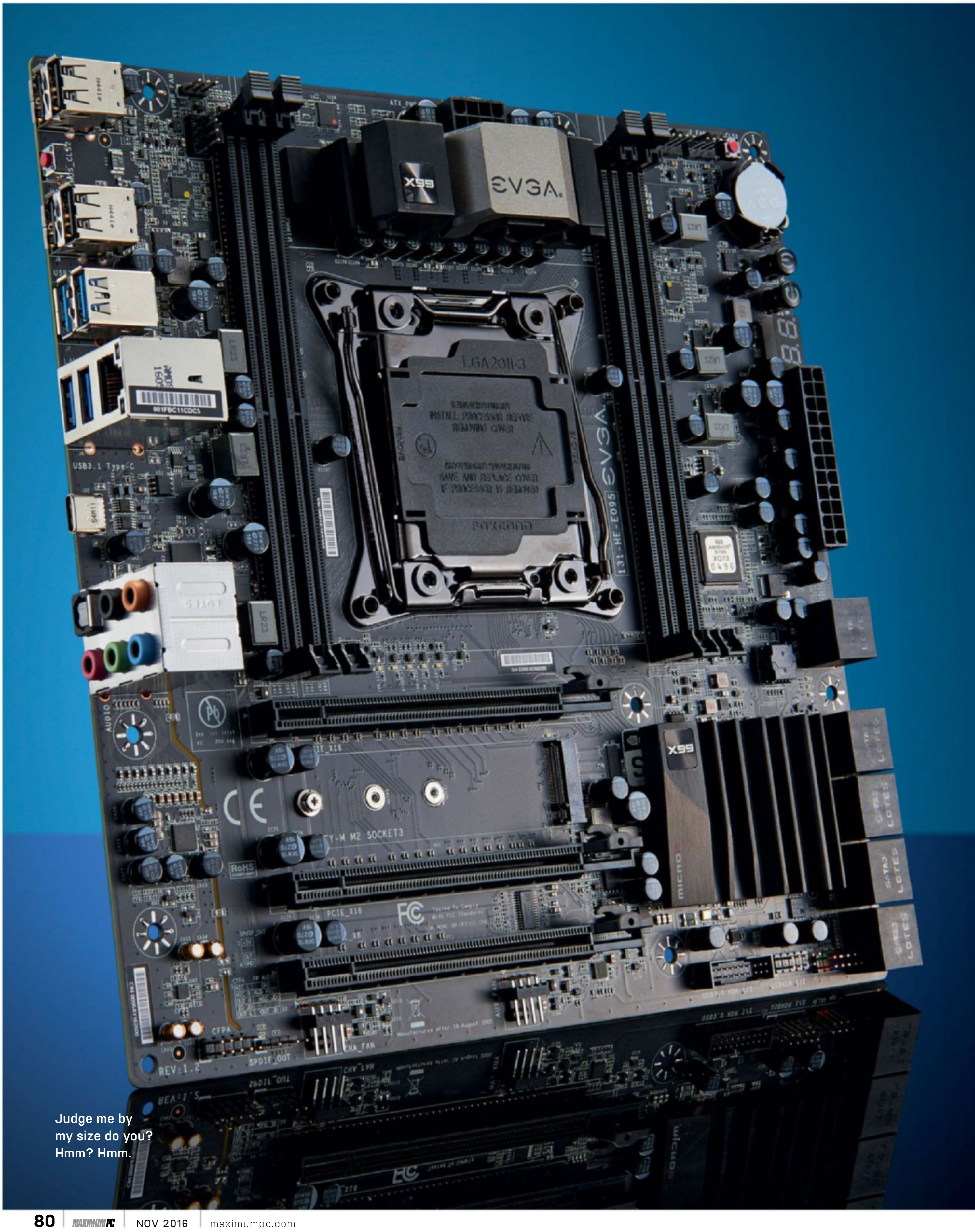
+ DIMINUTIVE Small; surprisingly powerful; versatile; plenty of connection options.

− REDUCTIVE Not for gamers; relatively pricey, considering extras required.

$650, www.intel.com

SPECIFICATIONS

Processor	Intel Core i7-6770HQ
Graphics	Intel Iris Pro Graphics 580
Memory Support	32GB 2,133MHz DDR4 SO-DIMM
Storage	2x M.2 Type M 22x42 or 22x80 SATA or PCIe SSD
Ports	Thunderbolt 3 with USB 3.1 support, 4x USB 3.0, Gigabit LAN
Connectivity	1x RJ45, 802.11ac, HDMI 2.0, Mini DisplayPort 1.2
Size	8.3 x 4.6 x 1.1 inches



Judge me by my size do you? Hmm? Hmm.

EVGA X99 Micro 2

X99 microATX perfection?

THE X99 PLATFORM is incredibly attractive. Six cores or more, quad-channel memory, plenty of PCIe lanes, expanded storage options, the list goes on. But for those looking to move to a smaller form factor in the process, options are limited. MicroATX and smaller X99 boards are few and far between. There's a grand total of one ITX X99 board, and four microATX ones—slim pickings indeed. And when you're looking for the perfect motherboard to round out a slick new themed build, well... let's just say it's a little challenging.

EVGA's X99 Micro 2 mobo, then, provides a good base for any builder looking to put a well-rounded build together. Aesthetically, it's gorgeous. With a lightweight metallic rear I/O cover, black heatsinks, and a stunning mix of black PCB and limited white LED lighting, it's absolutely on point when it comes to overall design. Its neutral color palette will work inside any build you place it in, and, thankfully, EVGA has removed the black and red capacitors found on its previous edition.

BYE-BYE SATA EXPRESS!

As far as expandability goes, obviously options are a little more limited than on the larger ATX boards. By default, you only have access to four DIMM slots, for a single set of quad-channel memory, as opposed to the full eight. There's access to three PCIe slots (configurable as either 1x16, 2x16, or 3x8), there's a single x4 M.2 socket, and SATA support is covered with 10 6Gb/s ports. Although there's no hint of SATA Express here, that's hardly a loss in our eyes. That aside, the board is exceptionally clean and exceedingly well rounded. There's an on-board power and reset button, diagnostic LED display, USB 3.0, and no fewer than five PWM fan headers, with two being right-angled.

So, it's feature-rich, but how does it perform? Well, we'll be honest: almost like every other X99 motherboard we've tested. As far as the platform goes, there's very little difference between boards outside of LN2 support and expanded power phases, for those lucky enough to net themselves a well-balanced overclocking processor. Compared to the full-sized Asus X99 Sabertooth, the Micro 2 scored slightly higher in both Cinebench R15 and Tech ARP's x264 benchmark; there was less than a 0.62GB/s difference in memory bandwidth; and overall performance was pretty much the same. What did impress us was the reduced power draw, with the Micro 2 sucking 63W from the wall at idle, and 349W at load. Although not as low as the Sabertooth, it stomped under Asus's latest X99 Strix Gaming. Speaking of gaming, yet again we scored an impressive average of 42 frames per second in the *Far Cry Primal* 4K benchmark, but with a slightly lower overall score in 3DMark Fire Strike Extreme, at 9,603.

The overclocking experience on the EVGA X99 Micro 2 can only be described as curious. EVGA's BIOS is exceptionally clean. The overall layout is simple and straight to the point—there's no advanced mode buttons here—and mashing that Delete key draws you straight into the OC section. However, there are controls that we wish we had access to (power phase optimization, for instance), which both MSI and Asus provide access to—they seem to be hidden away here, locked behind imaginary walls. That aside, we managed an impressive 4.3GHz out of the Micro 2, on only 1.3V—the lowest we've seen to date. Although predominantly dependent on the chip, the motherboard does play a part in voltage control, usually through the control of VDrop—the voltage that is actually provided by the motherboard when the setting is input into the BIOS. In this case, the Micro 2 blew us away with a 0.1V difference between our prescribed setting and how much it actually needed to maintain that overclock.

So, does the Micro 2 satisfy our X99 needs? It definitely does. It's affordable, performs well, and in today's age of two-way maximum SLI and PCIe storage solutions, keeps us more than happy. Couple that with its sleek, yet sharp aesthetic, and EVGA is on to a winner. Expect to see this motherboard appearing in a custom build soon—boy, would it be a shame just to waste it! **–ZAK STOREY**

VERDICT

9

EVGA X99 Micro 2

⊞ **GARGANTUAN** Clean style; solid expandability; great value; on-board power; debug LED; good overclocker.

⊟ **MINI** BIOS limitations.

$200, www.evga.com

BENCHMARKS

	EVGA X99 Micro 2	Asus X99 Strix Gaming	Asus X99 TUF Sabertooth
Tech ARP x264 v5.0.1	37.09	**39.07**	36.43
Cinebench R15	1,765	**1,859**	1,711
SiSoftSan Memory Bandwidth (GB/s)	51.74	**54.21**	52.36
AIDA64 Memory Latency (ns)	74.4	**72.2**	73.1
CrystalDisk Read/Write (MB/s)	545/523	**550/530**	514/503
Power Draw Idle/Peak (watts)	**63**/349	67/365	75/**341**
Far Cry Primal @ 4K (fps)	**42**	**42**	**42**
3DMark Fire Strike Extreme	9,603	**9,734**	9,660
Maximum Overclock Achieved (GHz)	4.3	**4.4**	4.3

Best scores are in bold. All benchmarks performed with an Intel Core i7-6950X, 32GB of DDR4 2400 (4x 8GB), GeForce GTX 1080, and a Samsung 850 Evo 500GB.

SPECIFICATIONS

Chipset/Socket	X99/LGA 2011-3
Form Factor	MicroATX
Memory Support	64GB DDR4 @ 3,200MT/s
M.2/U.2 Support	1x M.2 PCIe x4
SATA Support	10x SATA 6Gb/s
Max PCIe Support	3x PCIe 3.0 x16 (x8/x8/x8)
Rear I/O	4x USB 2.0, 4x USB 3.0, 1x USB 3.1 Type-C, 1x Gigabit LAN, 8-channel audio + optical

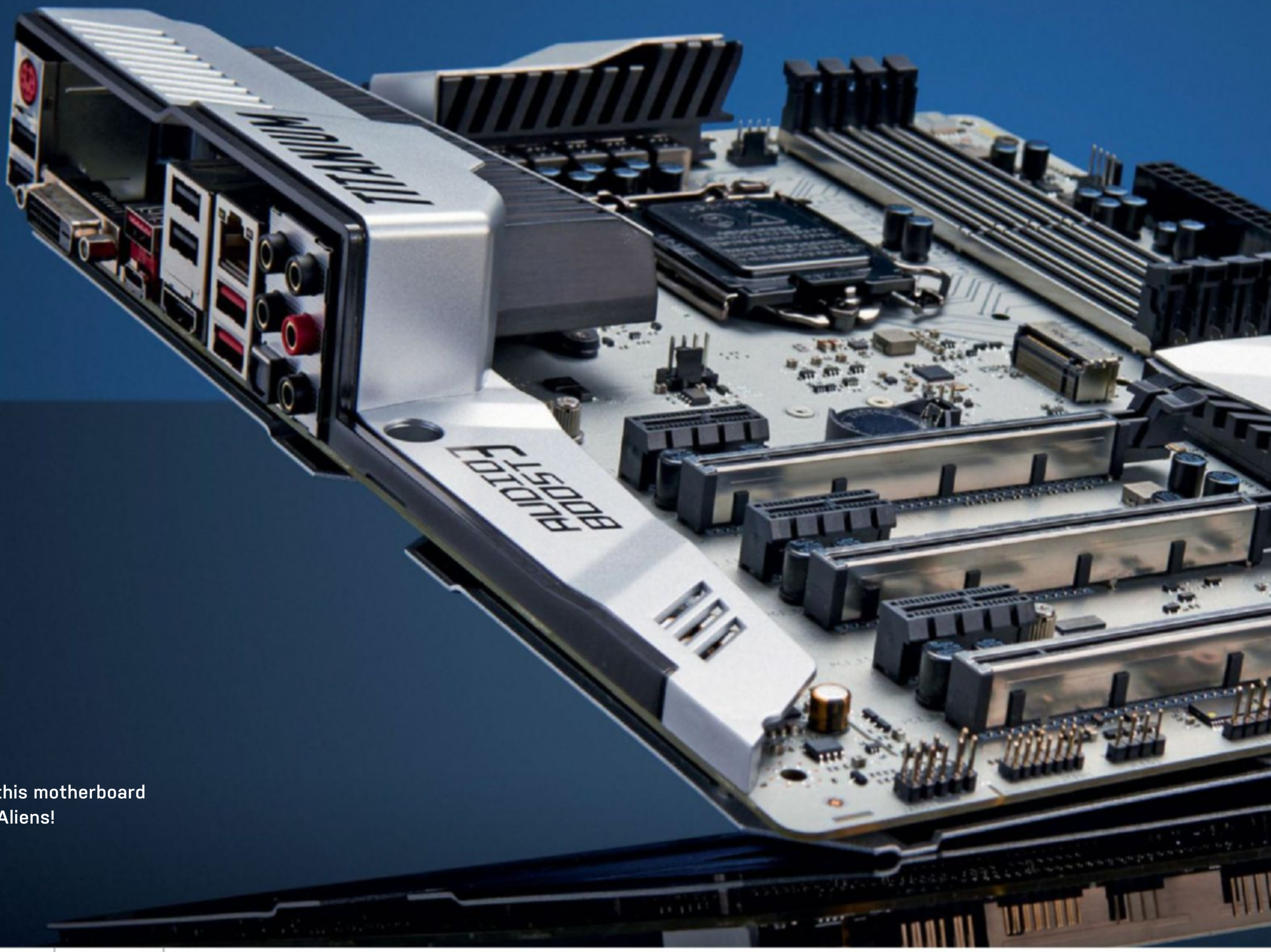
MSI Z170A MPower Gaming Titanium

How to nail the Z170 chipset

"**TWO MOTHERBOARDS** in one issue and it isn't a group test? Are you crazy, *Maximum PC?* Why do you keep tormenting yourselves like this?" Good question. This month has been particularly interesting for us; we finally garnered a press contact at EVGA for some much-desired review samples, and then, MSI sent us, absolutely totally on purpose, this exceptionally stunning, balls-to-the-wall, silver MSI Z170A MPower Gaming Titanium ATX motherboard. Try saying that five times fast, while drunk.

Poorly angled imagery aside (curse you crazy photographers), this motherboard is beautiful, and that's down to a couple of nifty additions, most prominent of which is that suitably succulent shiny silver PCB. Until now, we've never seen a PCB in silver. Yes, Asus introduced an all-white PCB in the form of the Sabertooth Sabranco, way back with the Z97 chipset in 2014. But an all-silver one? Well, that brings all sorts of complex challenges, certainly from a manufacturing standpoint. Couple that with an extensive aluminum rear I/O cover and a solid backplate, and you're looking at one standout product. A little niche, though, right? Absolutely. After all, there's a very limited number of themes this would work with, especially from a color perspective. Silver hardware is limited, and build schemes that come to mind are few and far between. Perhaps a black and silver water-cooled loop might fit the bill, with two Gigabyte GTX 1080s, and some swanky mirrored EKWB backplates? Owf—a boy can dream.

Alas, aesthetics are only half the story. What about connectivity and features? Well, for a $250 motherboard, you're completely spoilt. For your well-earned cash, you net yourself access to two (steel-reinforced) x4 M.2 slots, supporting both RAID 0 and 1; three (steel-reinforced) PCIe slots, running at max in x8x8x8; four dual-channel DDR4 (steel-reinforced) DIMM slots for all your crazy memory speeds, all the way up to and beyond 3,866MT/s; and, somewhat more interestingly, a single U.2 connector located below the SATA ports (not steel-reinforced), for all those Intel PCIe SSDs you're not buying yet. Why the steel? In short, it does two things: firstly, it strengthens the PCIe brackets, preventing you from causing too much damage to your, err, slots. And secondly, it reduces



Why is this motherboard silver? Aliens!

the potential amount of electromagnetic interference from your other components. Also, it just happens to be silver-colored, so it matches the board.

FIGURES OF FUN

As far as performance goes, it's as well rounded as we've come to expect. Processor performance was in line, clocking up 922 points in Cinebench R15 at stock, and 19.39fps in Tech ARP's x264 benchmark—about right for the Intel Core i7-6700K. Memory bandwidth was impressive, scoring just over 30.36GB/s in SiSoftSandra's benchmarks, and the MPower absolutely stomped over the latency tests in AIDA64, scoring an astonishing 53.7ns—far lower than any of the other X99 motherboards or competing brands. As always, gaming was consistent with every other motherboard ever, scoring the usual 42 frames per second in *Far Cry Primal,* and a nifty 9,478 points in 3DMark Fire Strike.

What was really impressive, though, was the MPower Titanium's overclocking performance. We dialed our 4.8GHz overclock into the BIOS at 1.4V, and then worked backward to see what minimum voltage the MPower could manage before giving up the ghost in stability. The result? 1.38V. That's 0.02V lower than we've seen from the likes of the MSI Z170A Gaming M7, which also reduced overall temperatures by 7 C. Sweet as.

Without a doubt, the MPower Titanium has a fantastically rich feature set, and exceptional overclocking performance, stability, and performance, bringing it in line with all the other motherboards we've ever tested, outside of overclocking. It also looks exceptional, the almost-ubiquitous reinforcement makes it beautifully comfortable to hold, and the added benefit of both U.2 and front USB Type C makes this motherboard a shoo-in for future-proofing your build. MSI's BIOS still needs a little reworking in our eyes, just to make it a bit easier to use, but otherwise this is a fantastic motherboard, and once you've plowed through the marketing rhetoric, it's well worth your time. **–ZAK STOREY**

SPECIFICATIONS

Chipset/Socket	Z170/LGA 1151
Form Factor	ATX
Memory Support	64GB DDR4 @ 3,866MT/s+
M.2/U.2 Support	2x M.2 PCIe x4, 1x U.2 PCIe x4
SATA Support	6x SATA 6Gb/s
Max PCIe Support	3x PCIe 3.0 x16 (x8/x16/x8)
Rear I/O	Intel Gigabit LAN, PS/2 combo port, 4x USB 2.0, DVI-D, HDMI, 3x USB 3.1, 1x USB 3.1 Type C, 1x optical audio, five-channel audio

VERDICT

9

KICK ASS!

MSI Z170A MPower Gaming Titanium

+ **ARGENTUM** Outstanding overclocking performance; exceptional latency; sturdy; consistent performance.

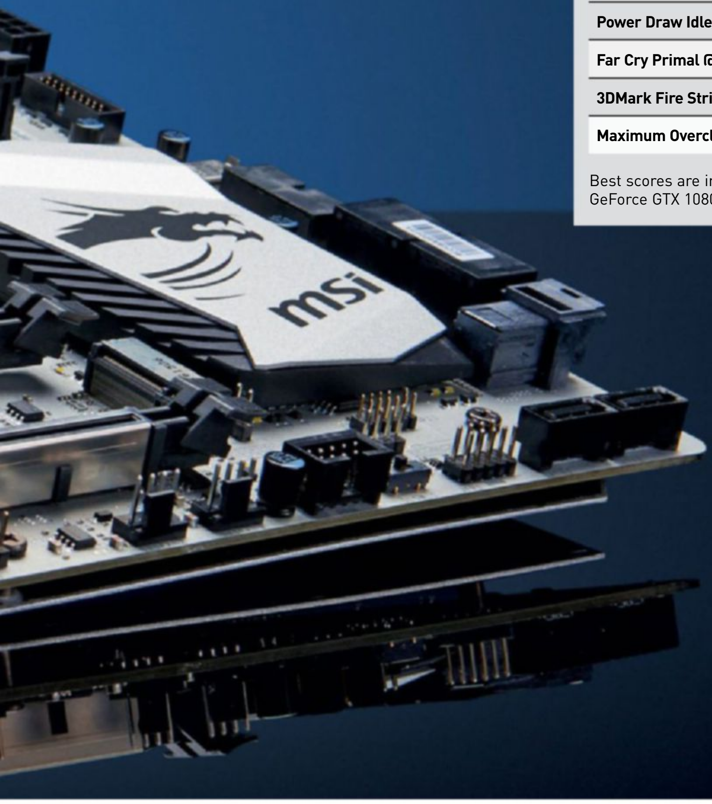
− **GLITTER GRAY** Color co-ordinated builds are difficult.

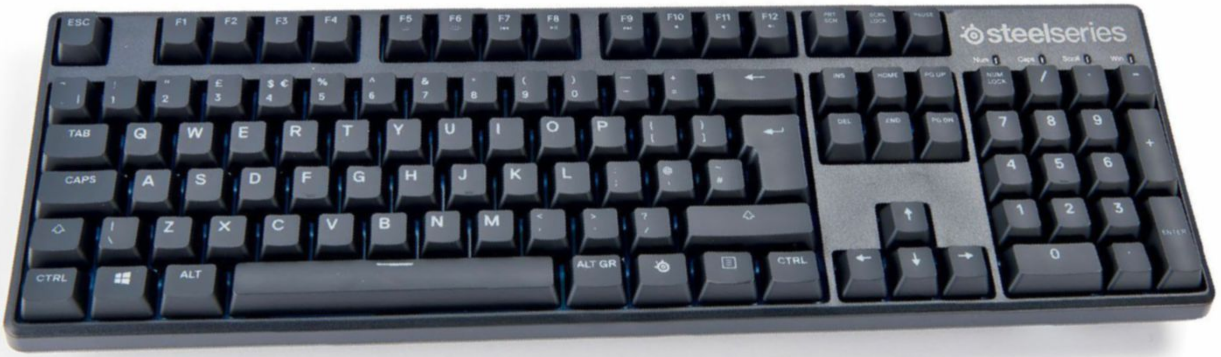
$250, www.us.msi.com

BENCHMARKS

	MSI Z170A MPower Gaming Ti	MSI Z170A Gaming M7
Tech ARP x264 v5.0.1 (fps)	19.39	**20.52**
Cinebench R15	**922**	**922**
SiSoftSan Memory Bandwidth (GB/s)	30.36	**31.27**
AIDA64 Memory Latency (ns)	**53.7**	54.6
CrystalDisk Read/Write (MB/s)	**548/517**	546/513
Power Draw Idle/Peak (watts)	**45/309**	47/311
Far Cry Primal @ 4K (fps)	**42**	**42**
3DMark Fire Strike Extreme	**9,478**	9,407
Maximum Overclock Achieved (GHz)	**4.8 @ 1.38V**	4.8 @ 1.4V

Best scores are in bold. All benchmarks performed with an Intel Core i7-6700K, 16GB of DDR4 2666 (2x 8GB), GeForce GTX 1080, and a Samsung 850 Evo 500GB.





SteelSeries Apex M500

Mechanical keyboards for all

KEYBOARDS AIMED AT gamers are so common at the moment, you'd be forgiven for being completely confused by them. A popular conceit is to brand them as some sort of esports tool, making you better at MOBAs in the same way that a Longhorns jersey makes you better at baseball. This sort of thing has worked in the world of meatspace sports for so long, it's no surprise it's crossed over.

The M500 is a budget model, merely "designed with the world's best esports teams," without mentioning who they actually are—a solid slab of matt black plastic, with enough metal in its base to give it a decent weight and purchase on your desktop. Each key sits atop the dependable favorite Cherry MX Red switch, giving it the easy up and down motion of the Dow Jones Average, but lacking the responsive click found in the Blue variant. There's no option to change the switches out, but the low level of force needed to activate them—they only have to move 2mm—makes the Reds a popular choice. With a rating of 50 million clicks, they should last a while, too.

There's some clever cable management going on underneath the keyboard, with three positions to choose from for the captive two-meter USB lead to exit from the back. This is such a simple idea, it's remarkable that it doesn't appear on more of the top-end keyboards—we've seen it a million times on budget-oriented models, yet it just doesn't seem to transcend beyond that price point. While under there, you'll find two feet to raise the keyboard's angle, and some shaped rubber pads that retain their grip, even with the feet deployed. It's thoughtful touches like this that can raise even a minimalist budget keyboard above its peers. There's a pattern underneath that's meant to increase the structural integrity of the keyboard, but we're less sold on that one. Perhaps keyboards bending in the middle is a common problem.

LOVE LETTERS

Thanks to the lack of bells and whistles on offer, one of the first things that strikes you as you look down at the M500 is the typeface used to cut out the letters in the key tops. It's a large friendly sans serif, and understands that a W is not an upside-down M. The punctuation, secondary functions, and numbers could be bigger, particularly the media keys, but with the blue backlight (it comes in one color only, as befits the nature of the unit) shining through, it's utterly clear and easy to read. Of course, being Cherry stems, you could swap the keys out for another set if you wanted, but the soft feel of these, even with their hard edges, means they're comfortable to use, and easy to differentiate if you're a touch typist.

SteelSeries's Engine software enables you to program macros (there are no dedicated macro keys on the board, so you're really looking at F keys here) and other customization options, including profile switching across compatible mice and headsets, as soon as you launch a game. The blue lighting can "breathe" across four levels of brightness, but there are no crazy peacock displays on offer. There's full anti-ghosting and 104-key rollover, if you're the sort of person who likes to mash multiple keys at once.

Logitech released a similar stripped-back unit recently in the form of its G610 (see the October issue for our review), and when more than one manufacturer does the same thing, it's a trend. This is a trend we can support, because no one really needs the world's most utility-focused nightclub dancing around their keyboard. A quick-start guide is included in the box, but none of the stickers or other assorted fluff that's likely to go straight in the trash. Concentrating on the basics is what makes a keyboard great, and creating something that feels damned good under the fingers is the key to forging a long-lasting relationship with anyone who sits and clacks keys all day. **–IAN EVENDEN**

VERDICT 8

SteelSeries Apex M500

+ APEX Stripped-back gaming keyboard that gets all the basics right.

– NADIR Versions with other switch types would be nice.

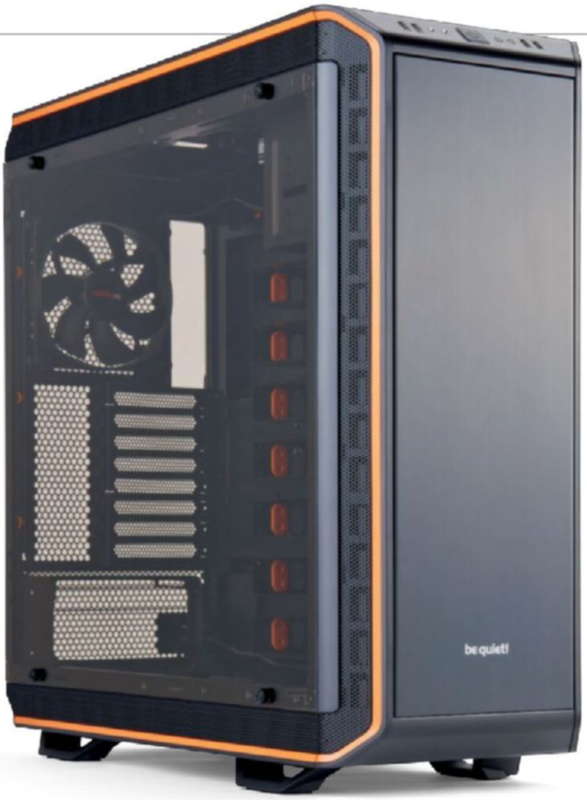
$100, www.steelseries.com

SPECIFICATIONS

Switch Type	Cherry MX Red
Form Factor	Standard
Media Keys	Integrated F keys
Macro Keys	None
LEDs	Blue
N-Key Rollover	104-key
Pass-Through	None
Dimensions	17.3 x 5.4 x 1.6 inches
Warranty	Two years

Be Quiet! Dark Base Pro 900

Just keep doing what you're doing, Be Quiet!



WHERE DO YOU START with a case like the Dark Base Pro 900? Seriously, this is difficult. This chassis is unlike anything we've ever seen before. At the beginning of the year, we reviewed Be Quiet!'s first chassis in the form of the Silent Base 800, and we'll be frank, it just wasn't up to scratch. It was a touch too plasticky, a bit fragile, and a little outdated. When the Dark Base Pro 900 was announced, we had a moment of head scratching, because there was a lot of room for improvement over the last series, and we certainly expected some changes, but what did we get? Well, it really was something else.

This case is flawless. In its base configuration, you're treated to seven hard drive cages, one rear-mounted motherboard SSD mount, a fan hub capable of supporting up to eight PWM fans, two LED strips, and a wireless Qi charger located on the top. There's a tempered glass side panel, cooling support for up to six separate 140mm fans, full ATX support, two 5.25-inch drive bays, and a glorious fan filter the length of the chassis, which you can remove from the front of the case. All of this is surrounded by a combination of brushed aluminum, steel, and sound-dampening panels.

MODULAR PERFECTION

Yet that's only part of what makes this case such an exceptional piece of hardware. What separates this spectacle from the crowd is what you can do with it. Let's list what is possible: You can swap the motherboard tray around and invert it, remove the hard drive cages, remove the 5.25-inch bays, remove the entire hard drive bracket, reorient the power supply slot, add support for a third 140mm fan in the front, add a pump/reservoir mount, attach the tempered glass panel to the other side…. You get the picture, if there's a component on here that you want to strip off, you can, with a Philips head screwdriver, and that's it—no pesky rivets to be found.

We've never seen such a flexible, or well-equipped case. Hypothetically, you could fit two 420mm radiators in here, with an additional 280mm on the floor, and a 140mm in the rear. Then swap the motherboard cage around and have an inverse system. The additional fan panel you can add once you've removed the 5.25-inch drive bay is also intuitively designed, because the door hiding the front of the chassis is a solid piece of aluminum and sound-dampening material, so there's no unsightly unused slots. Then there are the fan filters littered around the chassis. The bottom filter is fully removable from the front, which saves having to shift your case around. Then you have the top panel, which is easily removable via eight clips, enabling you to install and hide the three 140mm fans in the top of the rig, still with ample airflow, and allowing you to install chunkier radiators in the top of the rig.

Aesthetically, the combination of aluminum, steel, and tempered glass creates a beautiful full tower. The sound dampening feels lush and premium, and helps reduce the hum from the plethora of fans you can install. The choice of orange, silver, or black accents will also add an air of style to your build.

So, there's gotta be some criticisms, right? There just has to be. Honestly, we're a little stumped on this one. Short of the electrostatic death bag this chassis comes wrapped in, and the horrendously tightly packaged box, there's not a lot we can comment on. Any criticisms we've ever had with a case have been addressed; even the price is on point, at $250. Damn, Be Quiet! Just damn. –ZAK STOREY

VERDICT
9
KICK ASS!

Be Quiet! Dark Base Pro 900

+ **DARK GOD** Modularity perfection; brilliant build materials; tempered glass; wireless Qi charger; huge cooling support; excellent modding potential; price.

− **TOO DARK** Static bag.

$250, www.bequiet.com

SPECIFICATIONS

Form Factor	Full tower
Motherboard Support	E-ATX, XL-ATX, ATX, M-ATX, ITX
Colors Available	Orange, black, silver
Window Available	Yes
3.5-Inch Support	7
2.5-Inch Support	15
Radiator Support	420mm roof, 420mm front, 280mm bottom, 140mm rear
Fan Support	3x 140mm front, 3x 140mm roof, 2x 140mm bottom, 1x 140mm rear
Dimensions	22.7 x 9.6 x 23.1 inches
Graphics Card Clearance	18.6/12.7 inches
CPU Tower Clearance	7.3 inches
Weight	32lb

beyerdynamic
Made in Germany
CE
T5p
beyerdynamic

Closed-back perfection.

Beyerdynamic T5p

The pinnacle of closed-back design?

WHAT DO WE LOOK FOR when evaluating whether or not a pair of headphones is any good? There's plenty of criteria, both quantitative and subjective. Frequency response, impedance, comfort, sound signature, connection standard, you name it—the list is almost endless. There are ways we can guess ahead of time, however; things we look for when seeking a pair of acoustic drivers capable of satisfying our highly demanding criteria. More often than not, it comes down to two specifications: impedance and frequency response. Although not the be-all and end-all of headphone design, a good frequency response indicates a potential soundscape untethered by the limits of the driver itself. Coupled with a high impedance cutting out any residual background noise, and you're usually on to a winner.

BEST HEADPHONES EVER?

With that in mind, Beyerdynamic's T5p headphones shine far brighter than any others we've ever reviewed. The frequency response is situated between 5 and 50,000Hz—that's 30,015Hz more than the perceived limits of human hearing. The impedance is a comfortable 32 ohms—not breathtaking, but low enough to allow a suitable versatility to these cans, ensuring they operate just as effectively on portable devices and smartphones as they do plugged into your favorite DAC. They come with a closed-back design, although you can opt for a semi-open variant, touting an impedance almost 20 times higher than from the likes of the T5p. And, of course, they have a circumaural over-ear design, with what can arguably be described as one of the most innovative internal driver constructions we've ever seen.

In short, they've got a spec list to die for. But, at almost $1,100, that's what you'd expect. The overall styling of this beautiful pair of cans is exceptional. The metal frame and exterior aluminum earcup plates lend an air of class to the whole affair—the double-sided detachable cable adds to that—and the combination of leather, memory foam, and suede acts as suitably comfortable padding. The Tesla-dynamic drivers are situated internally in two diagonally angled enclosures, ensuring they direct sound efficiently into your ear canals. They also look baller, to boot.

We tested this particular set of Beyers on the positively modest (in comparison) Denon DA-300USB DAC. With Tidal as our baseline, the audio was phenomenal. There's almost no audible background noise, and the frequency response of the T5p was exceptional; the upper edge of the treble was crisp and well rounded, nothing was lost in the mids, and the bass was reassuringly comfortable. It's a reference sound signature—arguably flat, in as far as there's no additional EQ tinkering here. You're listening to how the artist intended the music to be heard, and you can feel it. It's moving, sleek, elegant, spine-tingling, the list of adjectives could go ever onward. Electronic and synthetic music fair a little worse than the likes of the more authentic acoustic, pop, and rock, but not enough to dissuade you from the sensual experience.

The T5p's biggest problem actually stems from making music sound too good. It's easy to pick apart the production values of a track by listening to it through these, with amateurish, alternative, and older music seemingly flat and basic in contrast to the more mainstream media you can enjoy from the charts. Adele, Ed Sheeran, and many other popular artists resonated well, yet the likes of Metallica, Lamb of God, and Rage Against the Machine just didn't have quite as much resonance as those with the bigger budgets. Even classical scores took a hit—Hans Zimmer is always going to be a winner in this regard, but those with a penchant for movie trailer music may be a little disappointed in some areas.

In essence, these headphones are nothing short of legendary. They're comfortable, innovatively designed, and stunning to listen to. The reference, yet well rounded, soundscape is exceptional, and coupled with a dependable DAC, the listening experience is second to none. Are they good value for money? Yes—but you need to have that money, a good set of ears, and be dedicated to the music you produce or listen to in order to truly appreciate just how good these headphones are. Otherwise, you might be better off opting for something a little more affordable from this German manufacturer—both the 1770 and new 1990 Pros come to mind in that regard. **–ZAK STOREY**

VERDICT
9
KICK ASS!

Beyerdynamic T5p

+ **TITAN** Breathtaking soundscape; exceptional comfort; innovative design; almost good value; peak of dynamic technology.

− **TIPPLE** Er, nope.

$1,099, www.beyerdynamic.com

SPECIFICATIONS

Driver Type	Dynamic Tesla Neodymium
Impedance	32 ohms
Frequency Response	5Hz–50kHz
Design Style	Closed back
Connectivity	3.5/6.35mm analog
Weight	12oz
Cord Length	4.5 feet

Turtle Beach Elite Pro Headset

A well-built triumph for design quality

BOTH ELITE AND PRO, this "tournament" headset is Turtle Beach's attempt to weld some esports cool points to a brand that's always been known for solid peripherals.

It uses a straightforward 3.5mm plug to connect to your PC, instead of a fancy digital USB connection, using the four-pole type of connector seen on a cellphone hands-free kit to integrate its microphone signal. Check that the headphone socket you plug it into supports this if you want to use the removable mic. Anyone in need of more options can get the optional Tactical Audio Controller (yes, really), which acts as an external USB soundcard, and costs the same as the headset itself. There's a noise canceling mic upgrade, too, offering "professional grade chat performance" (who writes this stuff?) for $30 more.

The Elite Pro is a serious investment when you're able to pick up cans and a mic for less than $20 online, so it had better be worth it. If you measure that worth in terms of comfort, it certainly is. After a head-scratching two minutes spent trying to work out how the cable (included in the box, but hidden so well that the packaging contains a message and an arrow pointing to it) fits, it snaps home solidly, and we finally notice the orange flash and shaped plastic that's meant to guide it in. A designer probably spent a week working on that, and is proud to have created such a foolproof method of attaching the cable right first time. Sorry, Mr Designer. Plugging in the bundled mic—omnidirectional, on a bendable stick—was similarly straightforward.

Once over our stupidity attack and wearing the headset, it reveals itself to be supremely comfortable. The ear cushions are gel-filled and cool against your skin, the headband pressing them lightly into the sides of your head to cut out a lot of background noise. With no sound coming from the headphones, we couldn't hear ourselves typing as long as we skipped over the keys like a ballerina. A heavier action on a mechanical keyboard could be picked out, as there's no noise-canceling. Ramp up some music or gunfire, and you'd be hard-pressed to be distracted by anything less than a civil defense siren.

DO ADJUST YOUR SET

The first time you put it on, the headband adjusts to your head, with two sliders above the orange pivot points (which look like a weak spot, but after some rough twisting, seem quite tough), and height adjustment below, enabling you to raise and lower each cup. The pivots enable you to twist the headset so it lies flat on a table, if that's your thing. The cord attaches to the right-hand cup, and isn't very long—something to watch out for if you're not using the TAC, and need to run it to the back of your PC. There's a useful volume wheel and mic-muting button halfway along its length.

Sound quality, once adjusted to fit your head, is extremely good. There's no Dolby Headphone cleverness on offer—these are stereo through and through—and without the use of the Tactical Audio Controller, they really are just dumb headphones (this means you can use them with your cellphone or console, too). While that's not necessarily a bad thing, it does make you look at something like the Corsair Gaming series of headsets, or the SteelSeries Siberia 800, with its wireless 7.1 sound, and wonder what you're paying for here.

The answer is thoughtful design and build quality, two things the Elite Pro delivers. And if having the most comfortable headset matters—particularly for people who wear them for long periods—this is a fine choice. For more options, such as noise-canceling or surround sound, you'll have to look elsewhere. **–IAN EVENDEN**

VERDICT 8

Turtle Beach Elite Pro

➕ **COWABUNGA** Extremely comfortable; decent sound; fully adjustable.

➖ **SHELLSHOCK** Simple stereo headphones; not much for price; expensive accessories.

$200, www.turtlebeach.com

SPECIFICATIONS

Driver Type	50mm dynamic
Impedance	32 ohms
Frequency Response	12Hz–22kHz
Design Style	Semi-open
Microphone Type	Omnidirectional
Connectivity	Four-pole/3.5mm
Weight	18oz
Cord Length	11 feet

Creative T4 Wireless

The top end of old-school 2.1 speakers

AT *MAXIMUM PC*, we tend to look at the extreme. Thanks to your support, we're in a very privileged position, being able to pick and choose some of the best products to review. Nowhere is this more obvious than with audio systems—DACs and headphones in particular. Anything with a signature acoustic resonance. However, these products, from the likes of Devialet, Beyerdynamic, and more, owe a massive debt to their precursors. In particular, we're talking about the 2.1 speaker systems of yesteryear. Speaker systems that were developed and created solely to make the most of the limited space provided by a desktop environment.

Alas, 2.1 speaker systems have almost hit an impasse. Finding a decent set of premium 2.1s today is hard work. The big brands—such as Logitech, Antec, Corsair, even Edifier—have almost stifled research and development into this type of audio solution. So, if you want the best of 2.1, where do you turn? To Creative. Today, a speaker system needs to do more than just pump out your favorite tracks from your rig. It needs to come with Bluetooth, have multiple inputs for other devices, look stylish, and provide thwomping bass, alongside a well-rounded soundscape at a price that's not too outlandish. And, in our eyes at least, Creative's T4 Wireless hits almost all of these marks.

OH SO SHINY

Opening the box, you're greeted with two small, stylish tweeter satellites, featuring a stunningly polished chrome top, black base, and single driver. Although you can't adjust the angle of these two speakers, they are naturally slanted slightly upward. And, thanks to their minuscule size, they're easy to position on even the most cramped of desks. The aluminum drivers provide a crisp and rich sound—there's a real depth to them, especially in combination with the subwoofer. Music is clear and precise; what you'd expect from a $300 2.1 speaker system. Is it audiophile grade? Of course not—it certainly doesn't compare to the likes of the Munro Sonics we reviewed two issues ago, but it's nowhere near that price point. Arguably, for value for money, it hits the nail on the head.

The subwoofer is impressive too, it's equally as compact as the tweeters; far smaller than anything from the likes of Edifier or Logitech that you can buy at this price point. But don't let its size fool you—the level of bass output is simply astronomical. There's a small dial located at the back of the device to adjust bass levels from 1 to 11; however, in our testing, we found that keeping it at the absolute minimum setting was perfect for keeping the trebles and mids prevalent enough. Your own experience may vary depending on the layout of your room, and the construction of your home.

Setup is relatively painless—simply position your speakers where you need them, hide your sub under the desk, then route the cables into the back of the woofer. There's an optical input for HD TVs, RCA-to-analog input for your system and to connect the speakers to the sub, and that's about it. Annoyingly, you can't detach the cables from the satellites, but otherwise there's little to complain about. If your cell phone has NFC, you can pair the Creative T4 up to the device wirelessly—simply hold your phone to the control pod, and you're good to go.

Things to note, then: The sound quality is solid, especially for the price; being able to adjust the bass via a dial is a plus; the expandability options are an additional benefit; the control pod is neat; and the whole setup looks gorgeous. Negatives stem from the pre-attached cables on the satellites, and a pesky power-saving control, which switches off the system after 20 minutes of inactivity. That aside, Creative really has nailed what a small 2.1 speaker system is all about. For those looking for a compact replacement for a set of cheap studio monitors, these might just fit the bill. **–ZAK STOREY**

VERDICT
9

Creative T4 Wireless

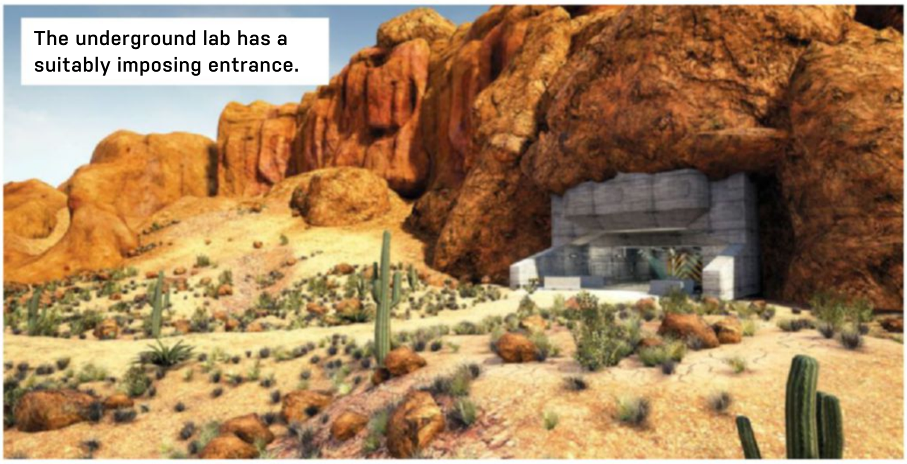
⊞ **TERMINATOR** Great sound quality; stylish; simple setup; versatile; cost-effective; compact.

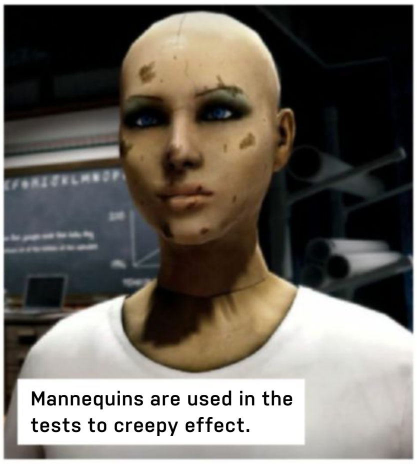
⊟ **TERMITES** Pre-attached satellite cables; power-saving mode.

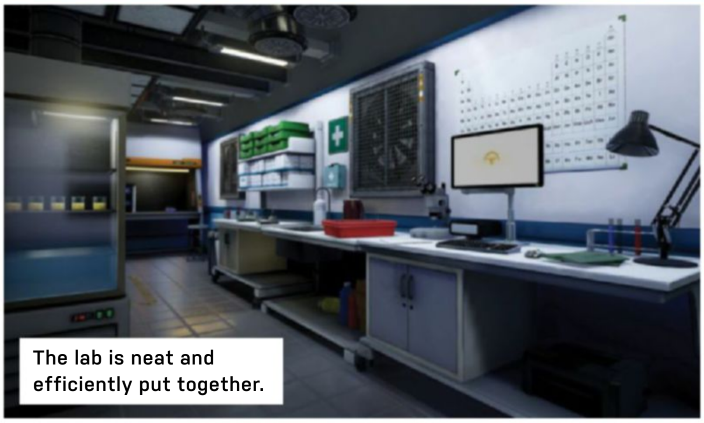
$300, www.creative.com

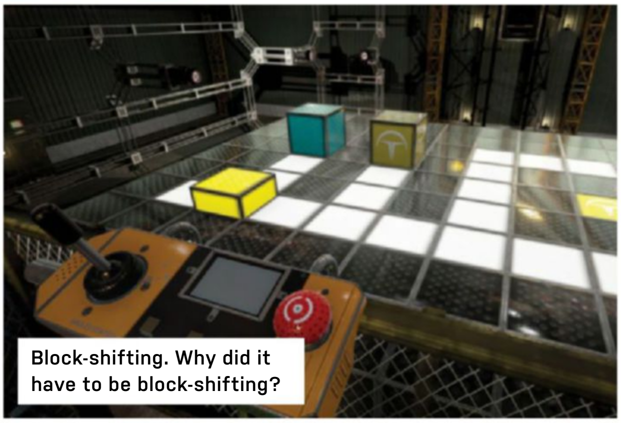
SPECIFICATIONS

Impedance	4 ohms
Connectivity	Optical, NFC, Bluetooth, RCA
Subwoofer Dimensions	8.5 x 9.3 x 11.4 inches
Satellite Dimensions	5.9 x 3.4 x 3.5 inches
Warranty	Two years


The underground lab has a suitably imposing entrance.


Mannequins are used in the tests to creepy effect.


The lab is neat and efficiently put together.


Block-shifting. Why did it have to be block-shifting?

The Assembly

Interactive story from a VR specialist

READING THAT A GAME is made for VR may give you the same sinking feeling as when a movie is made for 3D. Great—there will be lots of unconvincing CG, and loads of bits where something big and pointy is pushed toward the audience. So, in a medium that's entirely CG, what can a game built for VR offer that one for flat screens can't?

One thing is the control scheme. Among the limitations of the current generation of VR hardware is the unpleasant nauseous sensation some people get when moving. Developer nDreams clearly knows this, as *The Assembly* has one of the best VR control setups we've seen. Holding the left trigger pops up a ghost of your character, which can be moved using a combination of sticks and head movements. Get it in the right place, press A, and you warp to its location. The ghost is intelligent enough to bend over desks, and put its hands against doors, so you know if something's interactive. You can nudge your position with the left stick, if your warping is imprecise.

It's not a standard FPS control scheme, but it's not a standard FPS game; there are no enemies, no time limits, and you often get another go if you mess something up. Two intertwined stories—in one, a protagonist undergoes "testing" after being kidnapped as part of a job interview, while the other pieces together a detective story about disease outbreaks—play out in a mysterious science complex, all smoothly rendered by Unreal Engine 4. You break into offices, cause underwhelming explosions, and read other people's emails to discover their love stories and door codes; complete block-shifting puzzles like it's 1996, stab mannequins in the back, and attempt to manage a global pandemic, with no section lasting long enough to overstay its welcome.

Yet while they may be compact and nicely designed, they're not very exciting. The game has no sense of jeopardy or the impression that your actions matter. That's not to say there aren't any nice touches—discovering a crowbar triggers a comment about IT being action-packed—and the constant narrative monologue the characters keep up while you control them is well written and performed. In what is a puzzle game at heart, this may be appropriate, but it makes for a slow game. There's too much consulting of maps and emails for clues, and not enough pleasure at your own cleverness for working something out.

This is solid VR work from a studio that knows what it's doing, but like many helmet-based experiences, *The Assembly* feels slight. You'll have it all wrapped up in three hours or so, and in this cold world of impersonal offices, you're left feeling that the whole is somehow less than the sum of its assembled parts. –**IAN EVENDEN**

VERDICT 5

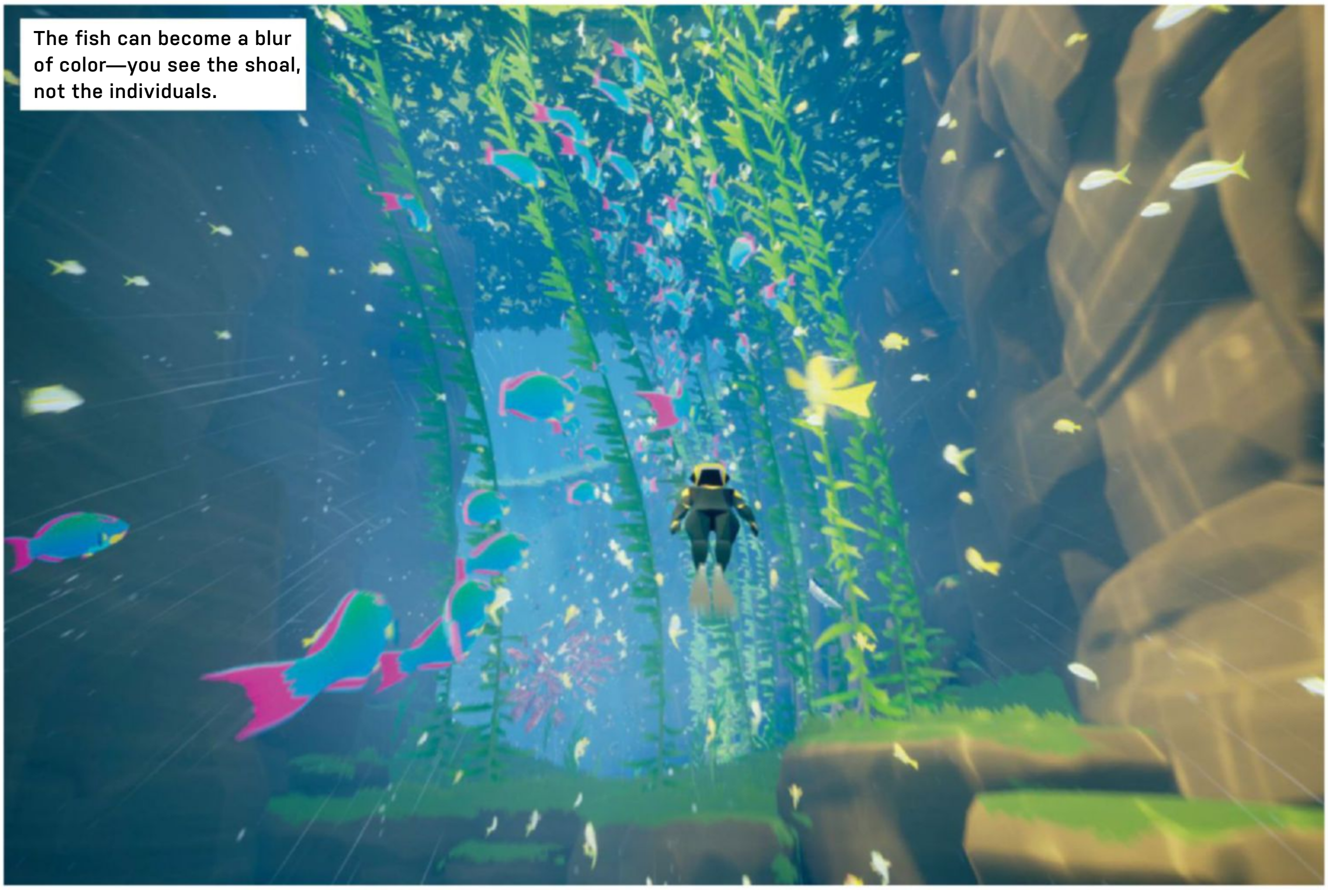
The Assembly

+ **ASSEMBLY** Clean, sharp looks; thoughtful VR; clever controls.

– **DISINTEGRATION** Lacks excitement; contains a block-shifting puzzle; quite short.

RECOMMENDED SPECS Intel Core i3-2120 3.3GHz or equivalent; 4GB RAM; Nvidia 700 series or AMD Radeon HD7700.

$20, www.ndreams.com, ESRB: T



The fish can become a blur of color—you see the shoal, not the individuals.

Abzû

This isn't *COD* any more

THE SECOND OF THIS MONTH'S non-combat games is more abstract, created by a team led by Matt Nava, the art director for PS3 waft-'em-ups *Flower* and *Journey*. Both games were critically applauded, so it's not much of a shock to see Giant Squid deviate little from the template here, taking things underwater in a move we should have deduced from the studio's name.

Abzû's protagonist is a diver, feline in appearance, apparently unencumbered by the need to breathe, and possessed of a wonderful grace in motion. She swims through a world inhabited purely by underwater creatures, sometimes accompanied by the drones she digs up from the sea bed, sometimes hanging on to some of the larger swimming creatures. Her intention seems solely to explore, appearing to take information about what she discovers to a strange tree-like creature who may exist between worlds. It's never explained, but it doesn't matter.

And it's beautiful—in a way that pulls you on to see what's next. Gliding through the swirling shoals of colorful fish is surely one of the closest things to paradise ever committed to flash memory.

Every species is from the real world, and the game encourages you to sit and watch as their simulated ecosystem carries on without you—statues are dotted around, and sitting in their heads allows you to meditate, the camera disconnecting itself from you, and swimming free with the fish as they shoal, chase, and eat each other.

The adventure is never explicitly spelled out—your play is completely unstructured. There is a way forward, and some sections feature a current that inexorably pulls you onward, but in most areas, you are free to explore and discover, even if that discovery is how much pulling lazy backflips while surrounded by orcas makes you smile.

Having that many fish on screen is going to push your graphics card, and *Abzû* has adopted a simple, polygonal art style. The fish are the star, as are the Mediterranean ruins you swim through, while your diver is more simply rendered.

The puzzles never get very complicated, generally amounting to finding two things that do the same thing, and activating them. There are secrets to be found, fish to be freed, and the aforementioned drones to repair, which are essential to your progress, because only they can cut through certain doors that block your path. The sea is far from infinite, penning you into arenas that teem with life until you find the way out.

Abzû is not a long game, but a gentle one, driven by the simple human need to explore, and see what's over that next hump in the seabed, and it's an essential play if gaming means more to you than the rattle of gunfire. **–IAN EVENDEN**

VERDICT 8

Abzû

+ OCEANIC Gorgeous to look at; wonderful soundtrack; relaxing.

− TITANIC Not the game for you if you're looking for fast, noisy gameplay.

RECOMMENDED SPECS 2.4GHz quad-core CPU; 8GB RAM; GeForce GTX 780 or Radeon R9 290X.

$20, http://abzugame.com, ESRB: E

LAB NOTES

TUAN NGUYEN, EDITOR-IN-CHIEF

The Ultimate in Speed

Who would want cable when fiber is on offer?

WHEN I LIVED IN LOS ANGELES, I had a 500/500 megabits down/up fiber connection: speed with incredibly low latency. After moving to the San Francisco Bay Area—Silicon Valley—I was left with cable or DSL. Cable took me down to 250/25Mb/s, which is a huge hit on the upload side. Forget about DSL in the bay. AT&T only offered a maximum download speed of 1.25Mb/s. Yes, one-point-two-five. Google Fiber isn't available in most places, and any chance of getting fiber was limited to office buildings.

Last year, Comcast announced it would be deploying its multi-gig fiber service in the San Jose area, but only in select areas. I kept calling, emailing, and tweeting the company in the hope that it would bring the service to my zone. Getting things up and running took several weeks. Because the area I live in doesn't have the latest wiring infrastructure, Comcast had to apply for permits to tear up the sidewalks, because the old underground cable network was going through straight dirt, and it needed to put in underground conduits.

A year later, fiber is in the ground from a node down the street, and runs directly into my house. It's so fast that there are no consumer routers that support it. I had to use a Comcast-provided 10-gigabit enterprise router by Juniper Networks. Thankfully, I'm wired for 10-gigabit.

The only problem: The Juniper router only has two 10-gigabit connections, and both are SFP+ fiber. Thankfully, I have a Netgear xs708e 10-gigabit switch with one SFP+ and eight copper ports. The Juniper unit plugs into the Netgear, and the rest of the house is wired to the Netgear. There's also no wireless routers or access points that can take advantage of Comcast's multi-gig service, so any devices on Wi-Fi are limited in speed. But that's OK as long as the wired systems have 10-gigabit Ethernet.

Fiber leaves cable at a standstill.

So how fast is my new connection? A blazing 2Gb/s in both directions—you can download a 14GB file in just one minute. That's faster than you can burn a Blu-ray disc, or transfer files to a thumb drive.

ZAK STOREY

Staff Writer

I've been thinking about how I can perfect my home setup. I've got a custom-built desk I crafted out of reclaimed wood, with a reinforced glass top, alongside the water-cooled rig from a few issues back, a sweet set of Corsair peripherals, a Denon DAC, and whatever premium headphones we have in for review. Problem is, I game a lot with my buddies, and swapping out from a dedicated DAC to a more gaming-centric headset is annoying. The solution? Well, we've still got the Razer Seiren Pro kicking about, and it's itching for me to take advantage of it. Problem is, how to mount it? I've decided to buy a Rode PSM1 studio boom. Problem solved? I'll let you know next month….

ALEX CAMPBELL

Associate Editor

Nvidia's Titan cards tend to be overpowered from a consumer standpoint. The Maxwell Titan X offered more power than the GTX 980 or 980 Ti, but at a much steeper price: $1,000. The gains in games couldn't justify its price for people who just wanted to play a bit of *CS:GO*. The new Pascal-powered Titan X is also pricey, at $1,200, but I've noticed that this Titan doesn't outperform the more gamer-minded GTX 1080 in any meaningful way (in games, anyway). The new Titan X is being sold as a professional card. Nvidia even mentioned that it was made for deep learning and AI, which is interesting. Sure, it can push pixels, but it might be better applied to building the first home HAL 9000.

Editors' Picks:
Digital Discoveries

Jarred Walton, Senior Editor, and Alan Dexter, Executive Editor, reveal their latest tech loves

ASUS RT-AC5300

If you're using a desktop PC, a wired Ethernet connection is still the best way to ensure a stable and lag-free connection, but more and more people are turning to laptops. Many laptops lack a dedicated Ethernet port, so you're stuck with Wi-Fi (or a USB dongle). Thankfully, 802.11ac can push some impressive data rates, and features like MU-MIMO improve throughput even when multiple users are actively transmitting large amounts of data.

Asus's AC5300 is the king of wireless routers, and it packs just about every feature imaginable into its spider-like chassis: MU-MIMO, QoS, beamforming, gigabit Ethernet, dual USB ports, and eight antennae. That last part is important, and it's what allows Asus to reach an aggregate AC5300 speed. For 2.4GHz clients, four spatial streams and 1024QAM reach up to 1,000Mb/s, and the two 5GHz networks each use four streams, with 1024QAM allowing up to 2,167Mb/s.

The three combined give a maximum of 5,333Mb/s—as fast as you'll get with 802.11ac. The newer 802.11ad standard might be tempting, with its higher throughput on 60GHz channels, but client adapters are scarce, and I'd rather have a great router using tried and tested standards.

$399, www.asus.com

SENNHEISER MOMENTUM M2

What was once new and exciting, quickly becomes mundane. When I first got the Momentums, I was blown away by the depth and clarity of audio. Warm, well-defined bass was beautifully balanced by rich mid-tones. Songs I've enjoyed for decades (yes, I'm that old) took on new textures, as notes that had been lost for years by lesser headphones were brought to the fore.

I've had these for a while now, though, so am I still amazed by every song I listen to? I'll admit that I'm not in a constant state of awe, as I was, but there are still moments that make me sit up and listen when I spot something I haven't before. When I'll just ramp up the music, sit back in my heavily padded gaming chair, and enjoy the moment. So, yes, while "amazed" may be pushing it, I'm definitely enjoying them still.

If there is a problem, it's that the location of my system means I wear them the wrong way around—the cable comes out of the right speaker, and I'd end up choking myself if I wore them as intended. Try as I might, I haven't managed to find a way of swapping the left and right audio round in Windows—annoying in some games. It's a minor point, though, and I'm still very much a fan.

$299, www.sennheiser.com

GEEK TESTED & APPROVED

Noble Chairs Epic Series

THERE'S SOMETHING to be said for the glitz and glam of a gaming den, where you can escape the rigors of daily life in favor of some beautifully crafted, exceptionally immersive pixels. So, how do you complete the experience? With what you sit on. We have custom desks, long benches, bespoke rigs, and high refresh rate, super-resolution monitors, so to cap it off, you need something comfortable to stick your posterior on.

That can come in many forms: a fold-up chair, an exercise ball (great for core strength), a cheap office stool, or perhaps something better. Something incredible. If the latter is your jam, you might be interested in one of the increasingly popular bucket gaming seats. Take this one from Noble Chairs. It's a combination of real dead cow and a polyethylene composite, with bespoke embroidery and memory foam padding, alongside additional lumbar support, and a suitably spongy headrest for when you need to get in a quick power nap. Is it good? It's exceptional. And if you don't fancy the colorful two-tone gamer fest, you can opt for the simple black-on-black variant instead.

That said, you can't ignore the criticisms. Firstly, there's the price. And secondly, it's a bucket seat. A bucket seat for gaming. Good lord—it's not like you're going to be thrown around while sitting at your desk. There's no denying it's comfortable, but the enveloping sides of these chairs is simply unnecessary. **–ZS**

$550, www.noblechairs.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Six-core benchmarks
> Heavyweight PCs
> Tricky header cables

Useful shortcuts

For Windows XP and Windows 7 users looking for their old troubleshooting commands in Windows 8 and 10, simply use Windows-X. Windows-I can be handy as well. **–Mark Seest**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We like readers bearing gifts. Right-clicking the Start button produces the same result, but keyboard shortcuts are definitely quicker. So well done, Mark.

Dream builds

Another great August issue! I read the comments section in the last issue about doing a microATX build, and I thought that would be great. Then I thought, you know what would be better? A water-cooled build. Then I thought, even better would be a Dream Machine in a CaseLabs Mercury S5. Epic, I say, very epic indeed. Just one more suggestion, I would like to see more benchmarks with a six-core CPU rather than its higher priced brethren. It just seems to me that the average person is using those chips more. Anyway just my 2 cents, keep up the great work. **–Daryl Austin**

Is *No Man's Sky* a nice place to retire?

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We did build a tiny water-cooled PC back in the July 2016 issue, which is worth checking out if you haven't done so already. But yes, water-cooling smaller machines is always very tempting, if often a tight squeeze. We're sure we'll be visiting it again soon. As for the Dream Machine, that always takes a lot of planning, and this year's Dream Machine is already sorted—you'll see the fruits of our labors next issue. As for your final point, we actually looked at the six-core Core i7-6800K last issue (pg. 83).

No man's time

Is anyone else afraid of the potential of *No Man's Sky* and VR to be the mother of all time sinks? I am hoping to retire there. **–Alain DeWitt**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: By the time you read this *No Man's Sky* will have landed, and you, like many others, will be contrasting the hopes for *No Man's Sky* and the (often crashy) reality. You will of course notice that we don't have a review of the game this issue—unfortunately there just wasn't time to get the review in, as it was released so close to deadline and we were prewarned that there was going to be a big day one patch. We will look at it in the future, but our initial impressions are that it isn't quite the trouble-free experience we were hoping for. Graphics driver updates are coming thick and fast as I write, though, so a few more days may make for a much better game. Even so, we'd recommend holding on to those retirement dreams a little while longer.

Heavy lifting

I was talking to a friend of mine (he owns his own custom build and computer store) and he had commented about how he started to dread moving his tower to his shop for its weekly cleaning. That got me to thinking: Why isn't the weight of cases and, in the instance of the Aventum 3 review, the entire system included in the specs? To be honest "you need a hand truck" is quite amusing, but not very helpful to some of us old codgers who have to lug this stuff around. **–Martin Jarvis**

STAFF WRITER ZAK STOREY RESPONDS: Good point, we'll take it into consideration moving forward. Some of these systems really are starting to get very hard to move, but then water-cooling does add a lot to the weight of a rig.

↘ submit your questions to: comments@maximumpc.com

RAID fight

I had to write in response to Ben Pearman's demands that you renounce support for RAID5. Pooh on that.

My Buffalo TeraStation HD-H1.0TGL/R5 (1TB) has been in continuous active service since 2006, its 4x 250GB Samsung IDE drives configured in RAID5 are still the original drives. The only failure has been the cooling fan, which I replaced with an Arctic F9 92mm. I've never lost data and the NAS has served Mac, Windows and Linux computers as well as being a DMZ FTP for my clients.

There's no one solution for everything, but, maintaining critical data accessibility even with a drive(s) failure is compelling enough reason to keep RAID5 around at least until mechanical drives disappear altogether.

–John Mullen

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Further proof that you can't please everyone all the time. Seriously though, while I'm sure there are plenty of readers that have been running RAID5 for years without any issues, there is a growing consensus that there are much better options available. The full-on feature explaining all of this is on the way to a future issue of *Maximum PC*, I promise. But until then, please can everyone just ensure that they have a proper back up in place.

Slot machine

I have an older ASUS motherboard that clearly does not support, nor has been updated to support, NVMe and PCIe SSDs. However, the Kingston HyperX Predator HH-HL from your article looks like a potentially great drive given my board's lack of NVMe support. You state that it's compatible with nearly all mobos, but to do your due diligence before buying. Well, I went so far as to call ASUS directly and I don't think the person I spoke to understood what I was asking. The board has longer PCIe x16 slots, but not the shorter "x4" slots. Aside from ASUS's very limited drive compatibility list, what information should I be researching to see if I could pull this drive off in my PC?

–Jeff Musial

STAFF WRITER ZAK STOREY RESPONDS: Fortunately what we can tell you from the get go is that from a physical compatibility standpoint you don't need to worry. In short, any PCIe card will work in a x16 slot, regardless of length of the PCIe connector. The first group of pins heading to the first notch for any PCIe card provides power, whilst the remainder is where data is transferred across. The reason cards like the HyperX Predator and even Intel's 750 series SSD are so short is because they are PCIe x4 devices, but they'll work fine in a x16 slot.

That said, without knowing your actual motherboard model, we can't do much digging for you. Your best bet is to query the motherboard make and model online with bootable PCIe SSDs. However if your board supports the AHCI protocol, a quick BIOS update should enable PCIe boot compatibility.

You're so vain

I am very much interested in building the mid-range system described in the article, [*Sep 2016, pg. 66*] but have one question: The article states "one problem we had with this particular combination of motherboard and case was with the USB 3.0 front panel connectors." "As you may have noticed, there's no grommet directly opposite it, and because the USB 3.0 front panel has such a stiff cable, we opted to not plug it in at all." My question: Was the cable not connected due to cosmetic reasons, or was the cable impossible to connect? **–Dave Weaver**

[NOW ONLINE]

THE PC GAMER TEAM'S PERSONAL RIGS

MSI
GEFORCE GTX
GEFORCE GTX
EVGA
1000 G

Ever wondered what sort of systems the *Maximum PC* team run at home? Well wonder no longer, because we've revealed exactly that in a post along with the rest of the *PC Gamer* team.

We love it when devs show us their rigs, and we were overwhelmed with responses when *PC Gamer* readers showed us their rigs. It was time we returned the favor. These are the systems we game on at home. How does your PC measure up?

You can read more online at http://www.pcgamer.com/heres-how-we-play-games/

STAFF WRITER ZAK STOREY RESPONDS: With this particular motherboard and case combination it would've been impossible to connect it directly. It wasn't vanity, we promise. It could've reached it easily enough, but because the USB 3.0 header is placed between two grommets and a metal panel it's just not possible. Couple that with the right-angle header, and you just can't route the USB 3.0 front panel cable around to plug it in to the board.

If the header was vertical it would've certainly made it easier to plug in to, but otherwise we just had no luck with it. And unfortunately, unlike a lot of the Skylake boards, the only other USB 3.0 header was situated on the bottom of the board, facing down towards that solid PSU cover.

That said, there are a number of alternative motherboards out there that look like they'd work just fine, either with multiple USB 3.0 headers located there, or just vertical headers instead.

The Asus Maximus VIII Hero, and the TUF Sabertooth have vertical ports, whilst both the MSI Z170A Gaming M7 and Gaming M9 ACK have two USB 3.0 headers, one vertical and one right-angled in those traditional positions to allow for a little more flexibility in a build like this one. I'll vouch for all of them in regards to performance too.

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THE BUILDS

BUDGET GAMER

INGREDIENTS

PART		PRICE
Case	Thermaltake Core V1	$48
PSU	EVGA G2 550W	$80
Mobo	ASRock H170M-ITX/ac	$95
CPU	Intel Core i5-6500	$205
GPU	EVGA GeForce GTX 1060 ACX 2.0 6161-KR **NEW**	$250
RAM	8GB (2x 4GB) G.Skill Aegis DDR4-2133	$35
SSD	240GB SanDisk Ultra II 2.5-inch SATA	$80
HDD	1TB Seagate Barracuda 7,200rpm 3.5-inch SATA	$50
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $859

AS WE LOOKED AROUND for new parts for this build, one thing became clear: The core components have been getting a little more expensive. Sure, the price for the ASRock H170M-ITX/ac dropped by $5, but that was made up for by the $5 rise for the Core i5-6500. Nearly every other component saw a slight rise of about $5 as well, with the notable exception of the 1TB Seagate Barracuda, which holds steady at $50 for now. The biggest price change we made is the video card. By switching from AMD's RX 480 to Nvidia's GeForce GTX 1060, we knew it was going to cost us. We still haven't seen inventory stay up to speed for the RX 480, and prices for available cards tend to be closer to $300, which is way inflated from the MSRP of $200. The RX 480 is a deal on paper, if you can find one. Instead, we went with EVGA's shorty GTX 1060, the 6161-KR. The card is the spiritual successor to the GTX 960 1961-KR that we've used so many times before.

MIDRANGE

INGREDIENTS

PART		PRICE
Case	NZXT Manta	$130
PSU	EVGA SuperNOVA G2 650W 80 Plus Gold	$100
Mobo	Gigabyte GA-Z170N-Gaming 5	$151
CPU	Intel Core i5-6600K	$235
Cooler	Corsair H100i v2	$97
GPU	MSI Gaming GeForce GTX 1070 Aero OC **NEW**	$410
RAM	16GB (2x 8GB) G.Skill Ripjaws V Series DDR4-2400	$68
SSD	250GB Samsung 850 EVO M.2	$104
HDD	Western Digital Black Series 1TB 7,200rpm	$69
OS	Windows 10 (*Download*)	$110

Approximate Price: $1,474

PRICE INCREASES STING at all levels, and the Midrange felt it just like the Budget build. However, a bigger budget provides more flexibility, and we were able to hold on to the majority of the parts we wanted. Intel's Core i5-6600K went up by $5, while the PSU saw a slight increase as well. The Samsung 850 Evo M.2 SATA SSD did go up significantly at some retailers, but we found it for $104 by shopping around. The big change was the video card. Unlike the Budget build, we could stick with our previous GPU, but we had to get a cheaper card model. MSI's entry here gets as close to the MSRP of $400 as we've seen. Most GTX 1070s fall between $420 and $450, which make the Founder's Edition that much more appealing. Luckily, this card has a blower design, too, which will help keep temperatures low. The Founder's Edition of the GTX 1070 is $450 pretty much across the board, so if you're willing to shell out a few extra dollars for the reference blower, go for it.

TURBO

THIS MONTH, we wanted to highlight what you can do when you forego the power and prestige of a high-end SLI setup. And when removing that second card creates a $700 void in the budget, boy, could we do a lot! One of the first things to notice, however, is that we're still sticking with the Haswell-E Core i7-5820K. The CPU still represents the entry-level X99 i7, with 28 PCIe lanes, and six cores. The newer Broadwell-E i7-6800K isn't much faster, but costs some $70 more.

We changed the motherboard to the Asus X99-A II, which is a generational upgrade from an old favorite, the X99-A. The X99-A II features USB 3.1 (Type-A and Type-C connectors), and supports up to 128GB of DDR4-3333—double the capacity of the older generation's 64GB of DDR4-3300. The board has support for the Asus Aura RGB LED lighting, too, if that's your thing. The budget breathing room also allowed for more memory and storage. A lot more storage. We went big with the SSD by getting a 1TB OCZ RD400 M.2. While the RD400 is a bit slower than Samsung's 950 Pro, it's still plenty fast. And with 1TB, you can fit just about anything you want on it. We kept a spinning hard drive for backup and bulk storage, and we were able to afford a 4TB WD Black. We rounded out the build with 32GB of DDR4-2666 from G.Skill, which is only one quarter of the motherboard's capacity (but more than the vast majority of people will use).

The crown is MSI's GeForce GTX 1080 Sea Hawk X, a hybrid card, which means it uses a closed-loop liquid cooler (in this case, a Corsair cooler) to keep temps in check. With closed-loop systems cooling the CPU and GPU, ambient temperatures in this build are a non-issue.

For more of our component recommendations,
visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Evolv ATX		$165
PSU	EVGA SuperNOVA G2 750W		$110
Mobo	Asus X99A II	**NEW**	$250
CPU	Intel Core i7-5820K		$385
Cooler	Corsair H100i v2		$105
GPU	MSI GeForce GTX 1080 Sea Hawk X 8GB	**NEW**	$762
RAM	32GB (4x 8GB) G.Skill Ripjaws V Series DDR4-2666	**NEW**	$140
SSD	1TB OCZ RD400 M.2 NVMe	**NEW**	$770
HDD	4TB WD Black 7,200rpm 3.5-inch SATA	**NEW**	$195
OS	Windows 10 (*Download*)		$110

Approximate Price: $2,992

UPGRADE OF THE MONTH

GTX 1080
NVIDIA

GEFORCE GTX 1060

Answering AMD's thrown gauntlet that was the RX 480, Nvidia retorted with the GeForce GTX 1060. The 1060, like the RX 480, is a powerful card that's aimed at the budget builder. And although it is more expensive than the RX 480's MSRP, it has enjoyed much better availability at time of writing. Both cards have similar performance, but in markets where the RX 480 is scarce, the GTX 1060 is definitely worth considering.

$250 (AIB), $300 (Founder's Edition), www.nvidia.com

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